

# USB-2416-4AO

USB-based 24-bit, Isolated, High-Channel-Count Multifunction DAQ Device with 4 Analog Outputs

## User's Guide

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## About this User's Guide

### What you will learn from this user's guide

This user's guide explains how to install, configure, and use the USB-2416-4AO so that you get the most out of its analog I/O, thermocouple (TC) input, digital I/O, and counter/timer I/O features.

### Conventions in this user's guide

#### For more information

Text presented in a box signifies additional information and helpful hints related to the subject matter you are reading.

**Caution!** Shaded caution statements present information to help you avoid injuring yourself and others, damaging your hardware, or losing your data.

**bold text**      **Bold** text is used for the names of objects on a screen, such as buttons, text boxes, and check boxes.

*italic text*      *Italic* text is used for the names of manuals and help topic titles, and to emphasize a word or phrase.

### Where to find more information

Additional information about the USB-2416-4AO is available on our website at [www.mccdaq.com](http://www.mccdaq.com). You can also contact Measurement Computing Corporation by phone, fax, or email with specific questions.

- Knowledgebase: [kb.mccdaq.com](http://kb.mccdaq.com)
- Phone: 508-946-5100 and follow the instructions for reaching Tech Support
- Fax: 508-946-9500 to the attention of Tech Support
- Email: [techsupport@mccdaq.com](mailto:techsupport@mccdaq.com)

# Introducing the USB-2416-4AO

## Overview: USB-2416-4AO features

is a multifunction measurement and control board designed for the USB bus.

The USB-2416-4AO is a full-speed (up to 1 kS/s), multiplexed 24-bit measurement system that provides up to 16 differential and up to 32 single-ended (SE) analog inputs. It offers software-selectable analog input ranges of  $\pm 20$  V,  $\pm 10$  V,  $\pm 5$  V,  $\pm 2.5$  V,  $\pm 1.25$  V,  $\pm 0.625$  V,  $\pm 0.312$  V,  $\pm 0.156$  V, and  $\pm 0.078$  V.

It also protects your computer by providing a minimum of 500 VDC input isolation between field wiring and the USB interface.

You can configure up to 16 of the analog inputs as differential thermocouple (TC) inputs. In thermocouple mode, the USB-2416-4AO includes built-in cold-junction compensation and open thermocouple detection.

You can add up to 32 single-ended or up to 16 differential channels by connecting the USB-2416-4AO to an AI-EXP32 expansion module. Each channel is software-configurable as single-ended or differential. For each channel pair configured differentially, you lose one SE channel.

The USB-2416-4AO has four 16-bit analog output channels with an update rate of up to 1 kS/s and an output range of  $\pm 10$  V.

The device has eight lines of digital I/O and two 32-bit counters. You can expand up to 24 DIO channels by connecting the USB-2416-4AO to an AI-EXP32 expansion module.

Six banks of removable screw-terminal blocks provide connectivity to the analog input channels, digital I/O lines, counter/timer channels, and analog outputs.

## Functional block diagram

USB-2416-4AO functions are illustrated in the block diagram shown here.

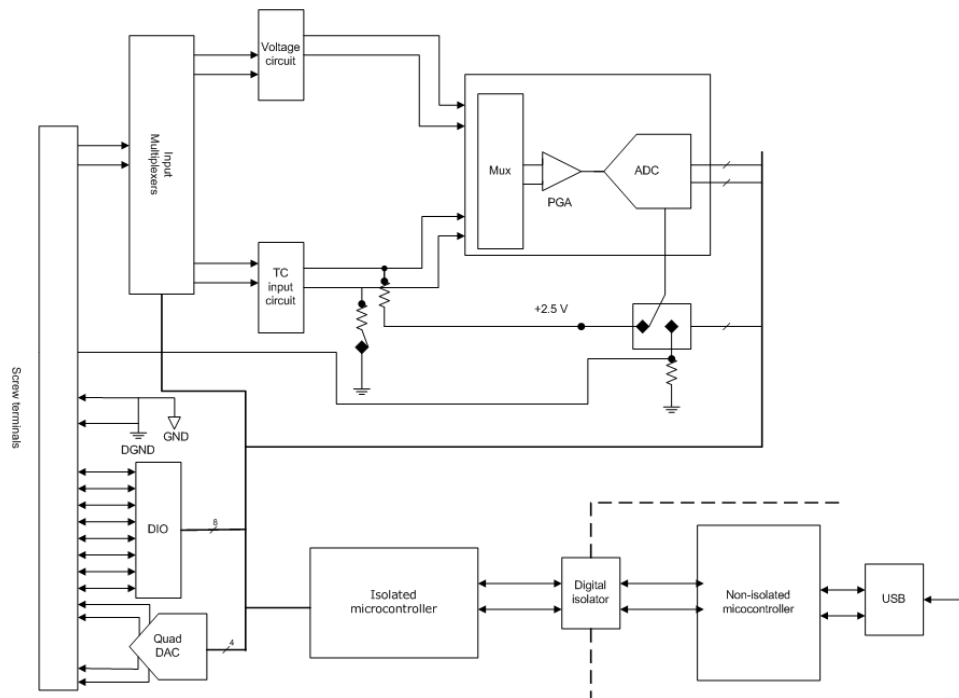


Figure 1. Functional block diagram

---

# Installing the USB-2416-4AO

## What comes with your USB-2416-4AO shipment?

As you unpack your USB-2416-4AO, verify that the following components are included.

### Hardware

- USB-2416-4AO
- USB cable (2-meter length)
- PS-5V2AEPS - 10 Watt regulated power supply plugs into the external power connector of the USB-2416-4AO.

### Software

- MCC DAQ CD

### Documentation

In addition to this hardware user's guide, you should also receive the *Quick Start Guide*. This booklet provides an overview of the MCC DAQ software you received with the device, and includes information about installing the software. Please read this booklet completely before installing any software or hardware.

### Optional components

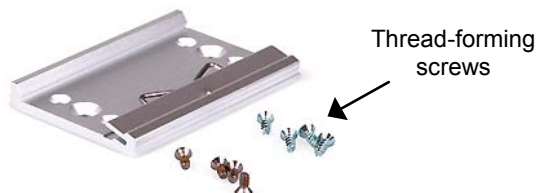
Expansion devices that are compatible with the USB-2416-4AO must be ordered separately. If you ordered the following product with your device, it should be included with your shipment.

#### AI-EXP32

Analog input expansion module adds up to 16 differential or 32 single-ended inputs to the USB-2416-4AO.

#### ACC-202 Din-rail kit

Accessory for mounting a USB-2416-4AO to a standard DIN rail. Use the thread-forming screws to attach the DIN rail clip to your device.



## Unpacking

As with any electronic device, you should take care while handling to avoid damage from static electricity. Before removing the USB-2416-4AO from its packaging, ground yourself using a wrist strap or by simply touching the computer chassis or other grounded object to eliminate any stored static charge.

If any components are missing or damaged, notify Measurement Computing Corporation immediately by phone, fax, or e-mail:

- Knowledgebase: [kb.mccdaq.com](http://kb.mccdaq.com)
- Phone: 508-946-5100 and follow the instructions for reaching Tech Support
- Fax: 508-946-9500 to the attention of Tech Support
- Email: [techsupport@mccdaq.com](mailto:techsupport@mccdaq.com)

For international customers, contact your local distributor. Refer to the International Distributors section on our website at [www.mccdaq.com/International](http://www.mccdaq.com/International).

## Installing the software

Refer to the *Quick Start Guide* for instructions on installing the software on the MCC DAQ CD. This booklet is available in PDF at [www.mccdaq.com/PDFmanuals/DAQ-Software-Quick-Start.pdf](http://www.mccdaq.com/PDFmanuals/DAQ-Software-Quick-Start.pdf).

## Installing the hardware

To connect the USB-2416-4AO to your system, turn your computer on, and then do the following:

1. Connect the PS-5V2AEPS power supply to the USB-2416-4AO's external power connector, and plug the other end into a power outlet.
2. Connect the USB cable to the USB-2416-4AO USB connector and to a USB port on your computer. A USB2.0 port is recommended.

When you connect the USB-2416-4AO to a computer for the first time, a **Found New Hardware** dialog opens when the operating system detects the device. When the message closes, the installation is complete.

The **power LED** (bottom LED) blinks during device detection and initialization, and then remains solid if properly detected. If not, check if the USB-2416-4AO has sufficient power. When the device is first powered on, there is usually a momentary delay before the power LED begins to blink, or come on solid.

**Caution!** Do not disconnect any device from the USB bus while the computer is communicating with the USB-2416-4AO, or you may lose data and/or your ability to communicate with the USB-2416-4AO.

## Connecting to an AI-EXP32 with the DSUB37 expansion connector

Use the 37-pin expansion connector to connect the USB-2416-4AO to an AI-EXP32 expansion module.

To connect the two devices directly to each other, follow these steps.

1. Disconnect the USB cable from the USB-2416-4AO.
2. Remove the external power cable from the USB-2416-4AO.
3. Connect the two devices together by inserting the AI-EXP32 DSUB37 connector into the DSUB37 connector on the USB-2416-4AO.



Figure 2. USB-2416-4AO directly connected to an AI-EXP32

4. Turn the connected modules over and secure the connection by screwing the connection plate to both modules, as shown below.



Figure 3. USB-2416-4AO secured to an AI-EXP32

5. Connect the external power supply to the power input port of the USB-2416-4AO, and then plug it into an AC outlet.
6. Connect the USB cable from the USB-2416-4AO to the host computer USB port.

Connect to a USB 2.0 high speed hub to achieve the highest transfer rate (480 Mbps). When connected to a USB 1.1 full-speed port, the transfer rate is limited to 12 Mbps.

## Configuring the hardware

Except for the DIO pull-up selection, all hardware configuration options on the USB-2416-4AO are software controlled. You can select some of the configuration options using InstaCal, such as the analog input configuration (single-ended or differential channels). When measuring from thermocouples, make sure you configure the channels for differential mode.

**Caution!** Turn off power to all devices connected to the system before making connections. Electrical shock or damage to equipment can result even under low-voltage conditions.

### Information on signal connections

General information regarding signal connection and configuration is available in the *Guide to Signal Connections*. This document is available on our web site at [www.mccdaq.com/signals/signals.pdf](http://www.mccdaq.com/signals/signals.pdf).

**Caution!** Always handle components carefully, and never touch connector terminals or circuit components unless you are following ESD guidelines in an appropriate ESD-controlled area. These guidelines include using properly-grounded mats and wrist straps, ESD bags and cartons, and related procedures.

Avoid touching board surfaces and onboard components. Only handle boards by their edges. Make sure the USB-2416-4AO does not come into contact with foreign elements such as oils, water, and industrial particulate.

The discharge of static electricity can damage some electronic components. Semiconductor devices are especially susceptible to ESD damage.

## Connecting the board for I/O operations

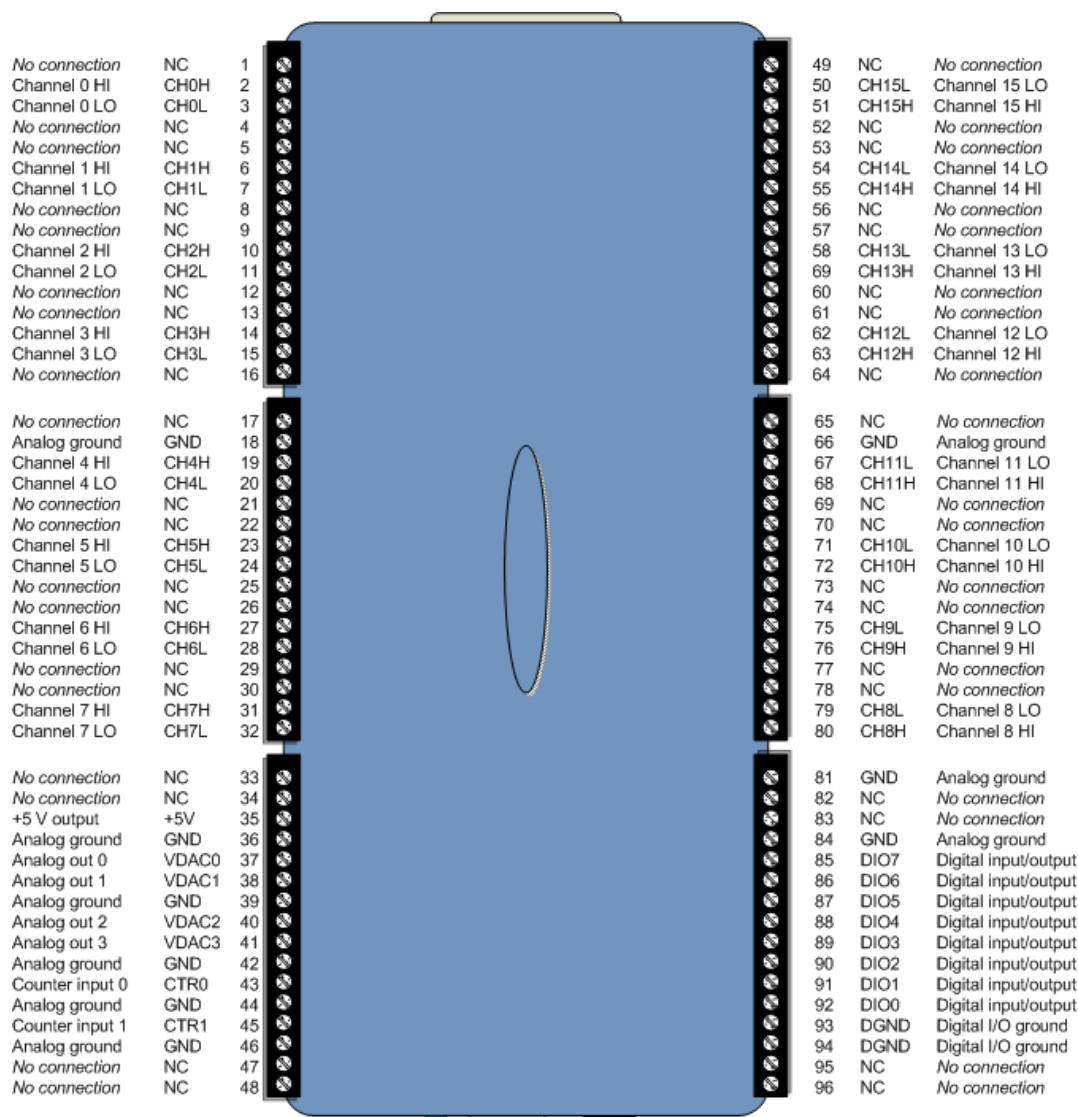
### Connectors, cables – main I/O connector

The following table lists the board connectors and compatible accessory products for the USB-2416-4AO.

Main connector specifications

|                                                                 |                                                                                       |
|-----------------------------------------------------------------|---------------------------------------------------------------------------------------|
| Main connectors                                                 | Six banks of detachable screw terminals                                               |
| Compatible accessory product for the 37-pin expansion connector | AI-EXP32 expansion board with screw terminals (connects directly to the USB-2416-4AO) |

## Screw terminal pin out – differential



|                 |       |    |  |    |       |                      |
|-----------------|-------|----|--|----|-------|----------------------|
| No connection   | NC    | 1  |  | 49 | NC    | No connection        |
| Channel 0 HI    | CH0H  | 2  |  | 50 | CH15L | Channel 15 LO        |
| Channel 0 LO    | CH0L  | 3  |  | 51 | CH15H | Channel 15 HI        |
| No connection   | NC    | 4  |  | 52 | NC    | No connection        |
| No connection   | NC    | 5  |  | 53 | NC    | No connection        |
| Channel 1 HI    | CH1H  | 6  |  | 54 | CH14L | Channel 14 LO        |
| Channel 1 LO    | CH1L  | 7  |  | 55 | CH14H | Channel 14 HI        |
| No connection   | NC    | 8  |  | 56 | NC    | No connection        |
| No connection   | NC    | 9  |  | 57 | NC    | No connection        |
| Channel 2 HI    | CH2H  | 10 |  | 58 | CH13L | Channel 13 LO        |
| Channel 2 LO    | CH2L  | 11 |  | 59 | CH13H | Channel 13 HI        |
| No connection   | NC    | 12 |  | 60 | NC    | No connection        |
| No connection   | NC    | 13 |  | 61 | NC    | No connection        |
| Channel 3 HI    | CH3H  | 14 |  | 62 | CH12L | Channel 12 LO        |
| Channel 3 LO    | CH3L  | 15 |  | 63 | CH12H | Channel 12 HI        |
| No connection   | NC    | 16 |  | 64 | NC    | No connection        |
| No connection   | NC    | 17 |  | 65 | NC    | No connection        |
| Analog ground   | GND   | 18 |  | 66 | GND   | Analog ground        |
| Channel 4 HI    | CH4H  | 19 |  | 67 | CH11L | Channel 11 LO        |
| Channel 4 LO    | CH4L  | 20 |  | 68 | CH11H | Channel 11 HI        |
| No connection   | NC    | 21 |  | 69 | NC    | No connection        |
| No connection   | NC    | 22 |  | 70 | NC    | No connection        |
| Channel 5 HI    | CH5H  | 23 |  | 71 | CH10L | Channel 10 LO        |
| Channel 5 LO    | CH5L  | 24 |  | 72 | CH10H | Channel 10 HI        |
| No connection   | NC    | 25 |  | 73 | NC    | No connection        |
| No connection   | NC    | 26 |  | 74 | NC    | No connection        |
| Channel 6 HI    | CH6H  | 27 |  | 75 | CH9L  | Channel 9 LO         |
| Channel 6 LO    | CH6L  | 28 |  | 76 | CH9H  | Channel 9 HI         |
| No connection   | NC    | 29 |  | 77 | NC    | No connection        |
| No connection   | NC    | 30 |  | 78 | NC    | No connection        |
| Channel 7 HI    | CH7H  | 31 |  | 79 | CH8L  | Channel 8 LO         |
| Channel 7 LO    | CH7L  | 32 |  | 80 | CH8H  | Channel 8 HI         |
| No connection   | NC    | 33 |  | 81 | GND   | Analog ground        |
| No connection   | NC    | 34 |  | 82 | NC    | No connection        |
| +5 V output     | +5V   | 35 |  | 83 | NC    | No connection        |
| Analog ground   | GND   | 36 |  | 84 | GND   | Analog ground        |
| Analog out 0    | VDAC0 | 37 |  | 85 | DIO7  | Digital input/output |
| Analog out 1    | VDAC1 | 38 |  | 86 | DIO6  | Digital input/output |
| Analog ground   | GND   | 39 |  | 87 | DIO5  | Digital input/output |
| Analog out 2    | VDAC2 | 40 |  | 88 | DIO4  | Digital input/output |
| Analog out 3    | VDAC3 | 41 |  | 89 | DIO3  | Digital input/output |
| Analog ground   | GND   | 42 |  | 90 | DIO2  | Digital input/output |
| Counter input 0 | CTR0  | 43 |  | 91 | DIO1  | Digital input/output |
| Analog ground   | GND   | 44 |  | 92 | DIO0  | Digital input/output |
| Counter input 1 | CTR1  | 45 |  | 93 | DGND  | Digital I/O ground   |
| Analog ground   | GND   | 46 |  | 94 | DGND  | Digital I/O ground   |
| No connection   | NC    | 47 |  | 95 | NC    | No connection        |
| No connection   | NC    | 48 |  | 96 | NC    | No connection        |

Figure 4. 16-channel differential mode pin out

### Differential connection guidelines

- When connecting differential voltage inputs to a "floating" voltage source, make sure there is a DC return path from each voltage input to ground. You make this path by connecting a resistor from each input to a GND pin (pins 18, 36, 39, 42, 44, 46, 66, 81, 84). A value of approximately 100 kΩ can be used for most applications.  
Leave unused input channels either floating or tied to GND (pins 18, 36, 39, 42, 44, 46, 66, 81, 84).  
Source impedances should be kept as small as possible to avoid settling time and accuracy errors.
- When configuring thermocouple sensors, keep any stray capacitance as small as possible relative to GND (pins 18, 36, 39, 42, 44, 46, 66, 81, 84) to avoid settling time and accuracy errors. For thermocouple channels, do not provide a return path to ground. This is done internally.

## Screw terminal pin out – single-ended

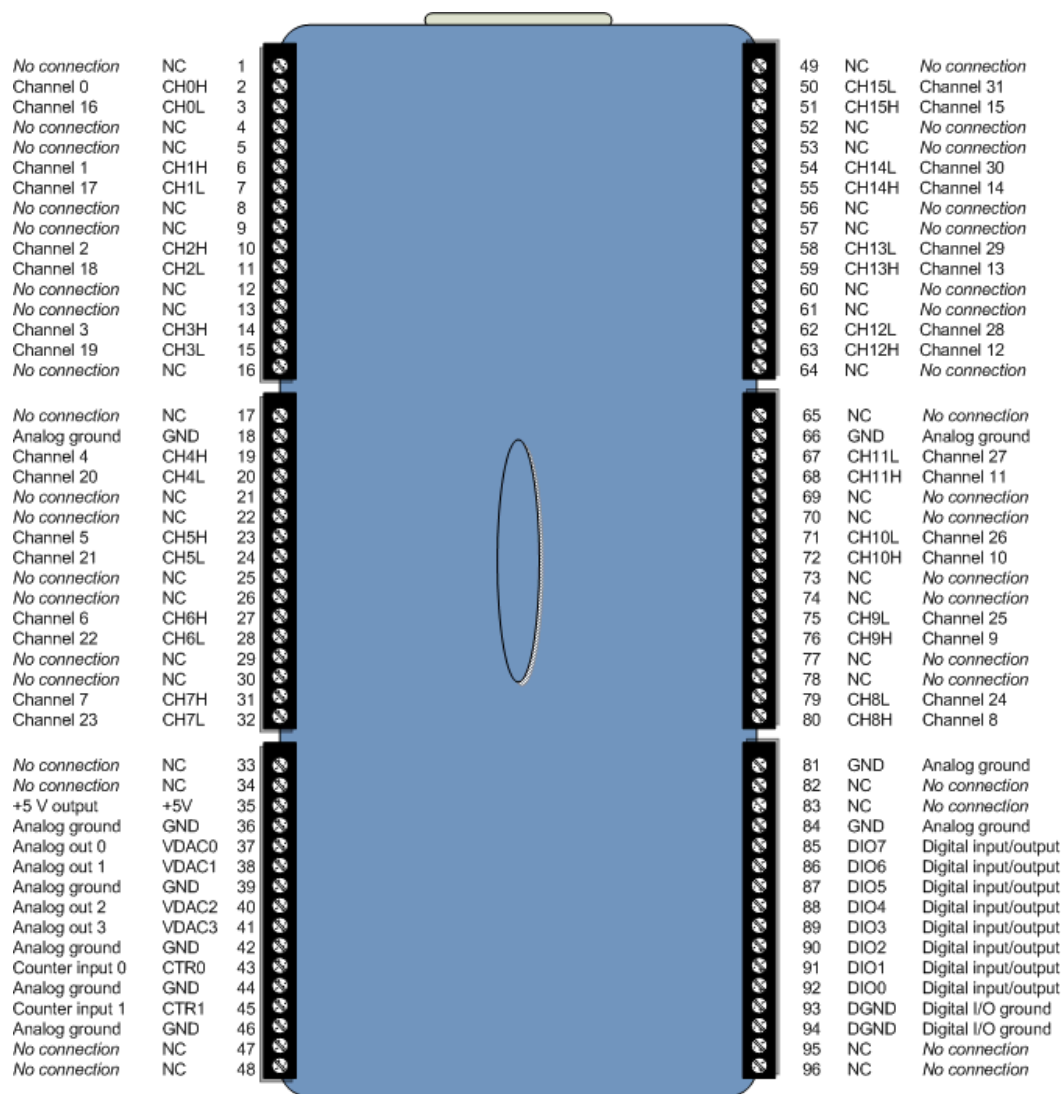


Figure 5. 32-channel single-ended mode pin out

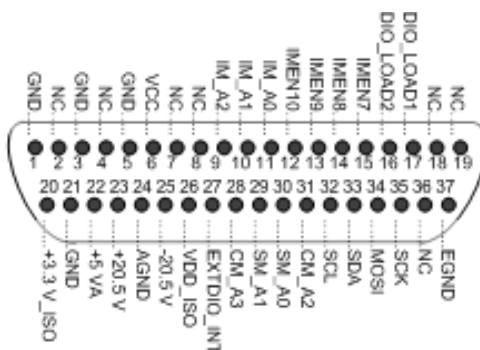


Figure 6. DSUB37 expansion connector pinout

The AI-EXP32 expansion port is intended to interface directly with the USB-2416-4AO. Do not attempt to use any of the expansion port pins for any other purpose.

Power-down the USB-2416-4AO before you connect it the AI-EXP32 expansion board.

## Functional Details

This chapter contains detailed information on all of the features available from the board, including:

- explanations of the physical device components
- a functional block diagram and mechanical drawings
- information on how to use the signals generated by the device
- diagrams of signals using default or conventional device settings

### USB-2416-4AO components

These USB-2416-4AO components are shown in Figure 7 and Figure 8.

- One USB connector
- One external power connector
- Two LED indicators (**Power** and **Activity**)
- One 37-pin DSUB expansion connector
- Six removable screw terminal blocks

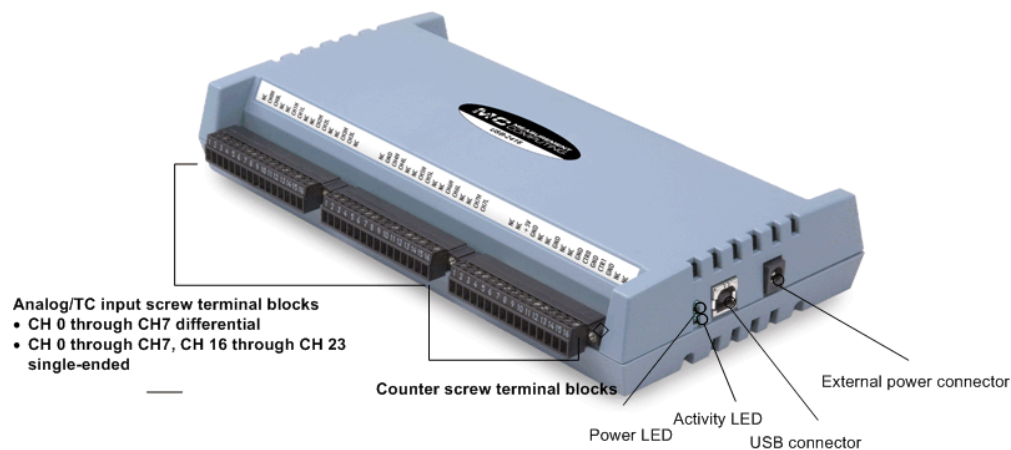


Figure 7. USB-2416-4AO components – front view

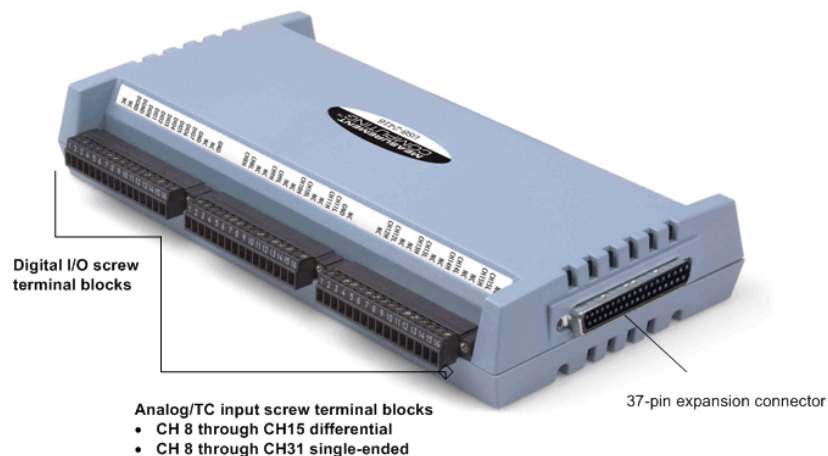


Figure 8. USB-2416-4AO components – rear view

## LEDs

When the USB-2416-4AO is connected to a computer, in its normal idle state both LEDs are lit solid green.

### Power LED

The Power LED is the top LED on the right side of the USB-2416-4AO housing.

The Power LED blinks when you plug the power supply into the USB-2416-4AO, and continues to blink while the device initializes the hardware. If it continues blinking for more than ½ second, then there is a problem with the USB-2416-4AO and you should cycle the power.

If an application issues a "blink LED" command, then the power LED blinks a few times.

### Activity LED

The (USB) Activity LED is the bottom LED on the right side of the USB-2416-4AO housing. It blinks rapidly when both the USB cable and external power cables are plugged in. It continues blinking rapidly while the device is connecting to the computer, and then turns solid.

Whenever the device receives a USB command, the Activity LED blinks off and then returns to solid green. When an analog in scan is running, the Activity LED blinks continuously.

## USB connector

The USB connector is on the right side of the USB-2416-4AO provides communication.

## External power connector

The USB-2416-4AO require external power through this connector to provide sufficient power for the USB-2416-4AO.

Connect the PS-5V2AEPS power supply to the external power supply connector. This power supply provides 5 VDC, 2 A power to the USB-2416-4AO.

## Screw terminal wiring

The USB-2416-4AO has six groups of screw terminals—three on each side of the housing. Each group has 16 connections. Pin numbers are identified in Figure 4 and Figure 5.

## Analog/TC input terminals

You can connect up to 32 single-ended analog input connections or up to 16 differential analog/TC input connections to these screw terminal pins.

- |                 |                   |
|-----------------|-------------------|
| ▪ CH0H and CH0L | ▪ CH8H and CH8L   |
| ▪ CH1H and CH1L | ▪ CH9H and CH9L   |
| ▪ CH2H and CH2L | ▪ CH10H and CH10L |
| ▪ CH3H and CH3L | ▪ CH11H and CH11L |
| ▪ CH4H and CH4L | ▪ CH12H and CH12L |
| ▪ CH5H and CH5L | ▪ CH13H and CH13L |
| ▪ CH6H and CH6L | ▪ CH14H and CH14L |
| ▪ CH7H and CH7L | ▪ CH15H and CH15L |

You can select a unique input range or signal type for each channel. For example, one channel could be used for volts and another for temperature.

When connecting differential voltage inputs to a "floating" voltage source, make sure there is a DC return path from each voltage input to ground. You make this path by connecting a resistor from each input to a GND pin (pins 18, 36, 39, 42, 44, 46, 66, 81, 84). A value of approximately 100 kΩ can be used for most applications. This does not apply to channels configured for thermocouple input, as they have their own internal reference.

Leave unused input channels either floating or tied to GND (pins 18, 36, 39, 42, 44, 46, 66, 81, 84). Source impedances should be kept as small as possible to avoid settling time and accuracy errors.

## Analog input mode

The USB-2416-4AO makes high-resolution voltage measurements in either a single-ended or fully differential mode. You can configure the USB-2416-4AO for the following voltage input ranges.

- $\pm 20$  V
- $\pm 10$  V
- $\pm 5$  V
- $\pm 2.5$  V
- $\pm 1.25$  V
- $\pm 0.625$  V
- $\pm 0.3125$  V
- $\pm 0.15625$  V
- $\pm 0.078125$  V

Each analog input channel has the following measurement parameters:

- signal type of volts or thermocouple type J, K, T, E, R, S, B, or N
- full scale voltage from -20 to + 20 VDC

## Thermocouple inputs

You can make up to 16 high-resolution differential thermocouple measurements with the USB-2416-4AO. Built-in cold-junction sensors are provided for each of the screw-terminal blocks, and any supported TC type can be attached to any of the 16 thermocouple channels.

Do not connect thermocouples as *single-ended*—doing so can cause false readings.

You do not need to use ground-referencing resistors because the analog front-end circuit level-shifts the thermocouple's output into the common-mode input range of the A/D.

When configuring thermocouple sensors, keep any stray capacitance as small as possible relative to GND (pins 18, 36, 39, 42, 44, 46, 66, 81, 84) to avoid settling time and accuracy errors.

The USB-2416-4AO also provides an open thermocouple detection (OTD) feature for each of the analog input channels configured for thermocouple measurement. This feature is automatically enabled as part of the overall acquisition process, and detects if an open-circuit condition exists at the thermocouple sensor.

The USB-2416-4AO provides electrostatic discharge (ESD) protection for each of the thermocouple inputs. However, before handling thermocouple sensors, follow standard ESD practices and discharge any accumulated ESD charge.

The USB-2416-4AO includes an ESD protection device at each of the analog input terminal block pins. If an ESD or transient voltage is coupled into the device, the input protection device(s) clamps the voltage to protect the thermocouple input circuitry from possible damage.

Once the thermocouple sensor is connected to the USB-2416-4AO, the configuration options have been selected, and the recommended 45 minute warm up has elapsed, the USB-2416-4AO is ready to make high-resolution differential voltage measurements.

Cold junction compensation (CJC) is needed to compensate for the additional thermal EMF's generated by connecting the thermocouple leads to the USB-2416-4AO terminal blocks.

CJC is performed using a high-resolution temperature sensor connected close to the USB-2416-4AO's terminal blocks. The USB-2416-4AO includes four separate CJC sensors—two on each side of the PCB. Software corrects for the additional thermocouples created at the terminal.

Once the A/D and CJC data is collected, the application software uses this data to linearize to an accurate temperature reading. The thermocouple linearization uses the latest NIST linearization coefficients for each of the eight thermocouple types supported by the USB-2416-4AO.

Figure 9 below shows a typical thermocouple connection.

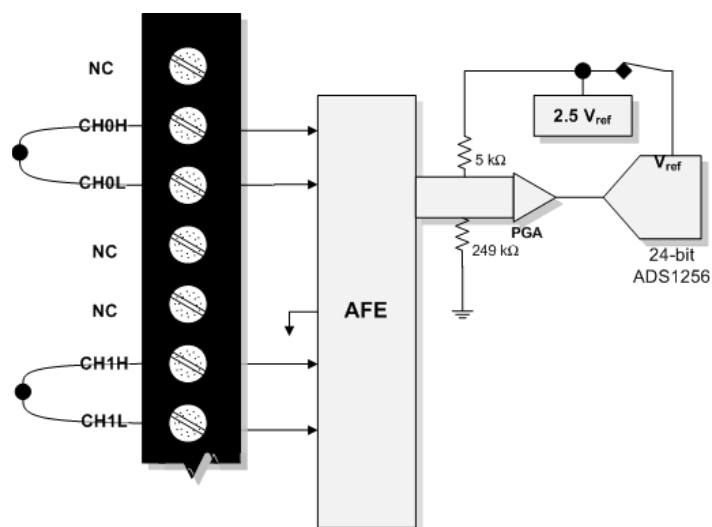


Figure 9. Differential thermocouple connection example

### Noise filtering, data rate, and throughput rate

Although the USB-2416-4AO A/D converter has a maximum data rate of 3,750 S/s, the actual throughput rate you observe for voltage and temperature data is determined by these formulas.

- Maximum single-channel throughput:

$$\frac{1}{\frac{1}{\text{data rate}} + 640 \mu\text{s}}$$

- Maximum multiple-channel throughput:

$$\frac{1}{\sum_n \left( \frac{1}{\text{data rate}} + 640 \mu\text{s} \right)}$$

where  $n$  is the number of channels

See Table 18 and Table 19 in the *Specifications* chapter for details.

This drop-off in throughput rate is due to the USB-2416-4AO's noise filtering feature. You can control the amount of the noise filtering by adjusting the data rate setting. By reducing the data rate, the averaging of samples increases, and noise drops correspondingly.

Figure 10 below illustrates this inverse relationship. This graph applies to the A/D converter only—do not expect this level of performance from the USB-2416 itself.

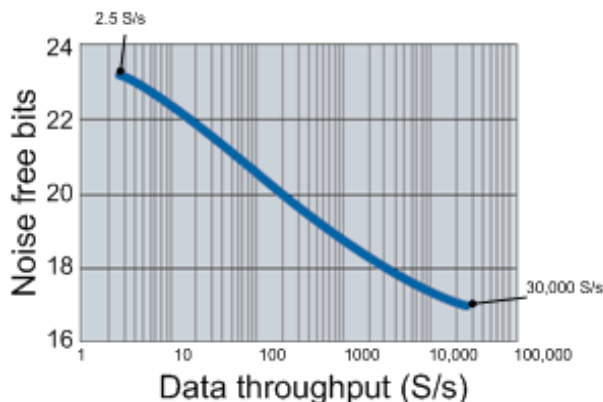


Figure 10. USB-2416-4AO A/D converter data rate vs. noise graph

If low noise is your main concern, you can operate the USB-2416-4AO at very low data rates starting from 2.5 S/s. At low rates, much of the noise is averaged out of the data, and issues such as reference noise become less important.

At higher data rates, higher-frequency noise sources are not averaged out and begin to be troublesome. These noise sources include the noise inherent in the A/D converter itself, which is not reducible.

Since thermocouples can pick up noise in your environment, select a data rate based on the primary noise frequency. For example, to reduce the effect of 60 Hz noise, select a data rate of 60 (or a sub-multiple of 60, such as 10 or 20).

### Multiple-channel throughput rates

When setting different sample rates for different channels, be aware that the all channels will be sampled within the same *sample window* based on the channel with the lowest sample rate.

For example, if you set a 10 Hz data rate for channel 0, and a 50 Hz data rate for channel 1, basically, both channels pass the same number of samples per second to the host computer. However, more averaging is performed on channel 0's samples; therefore, channel 0 is sampled at a higher resolution.

The USB-2416-4AO's A/D converter performs averaging, and the number of averages equals  $30,000/\text{data rate}$ .

In this example, channel 0 is sampled 3000 times over 100 ms, and all samples are averaged into one sample. Then, channel 1 is sampled 600 times over 20 ms, and samples are likewise averaged into one sample.

The final samples are available to you at a maximum rate of about 8 Hz (8.245 Hz).

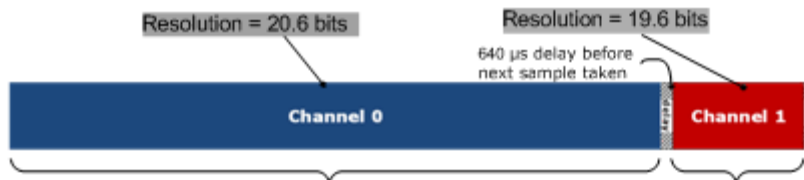


Figure 11. USB-2416-4AO data rate vs. resolution example

### Input isolation

The USB-2416-4AO is an isolated data acquisition device. The analog input, digital I/O, counters, and all the digital control/timing are referenced to an isolated ground as shown in the figure below. This ground is physically and electrically separate from the ground use by the circuit connected to the system bus interface.

Isolation provides a barrier between the host computer and potentially hazardous voltages by physically and electrically separating two parts of the measurement device.

- The *non-isolated* ground is common to the chassis ground of the computer, while the *isolated* ground is not.
- All analog measurements are made relative to the isolated ground. See Figure 12 for details.

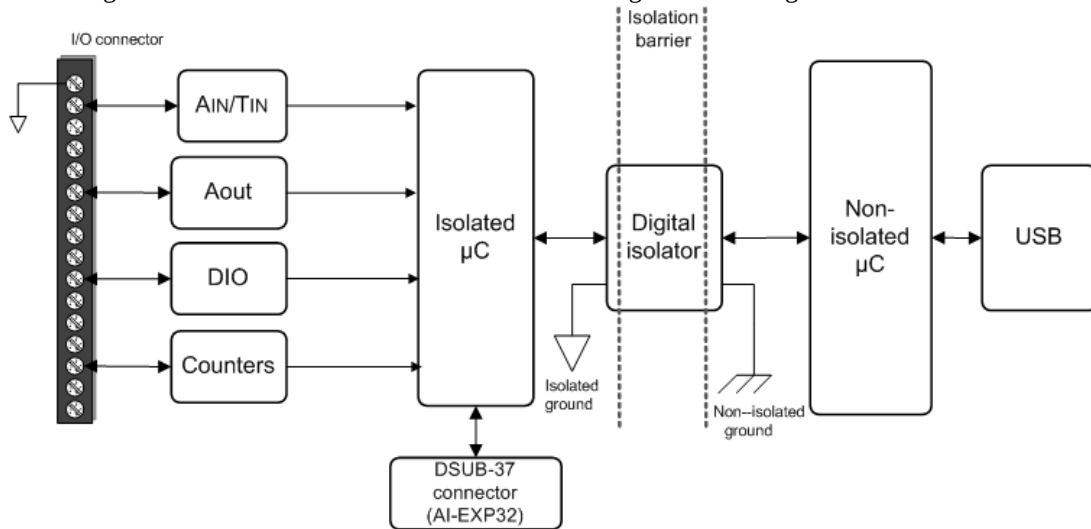


Figure 12. USB-2416-4AO input isolation diagram

When making measurements in industrial environments, DAQ devices can encounter hazardous voltages, transients, large common mode voltages and fluctuating ground potentials. Any one of these issues can seriously degrade the measurement accuracy of the device and possibly damage the measurement instrument. To overcome these issues, some DAQ devices provide physical and electrical isolation. Some of the benefits of isolation include:

- **Safety:** A DAQ device employing physical and electrical isolation helps to keep high voltages and transients from damaging the system-side host PC.
- **Ground loops:** Improper grounding of the signal source that the DAQ device is measuring is one of the most common sources of noise and measurement inaccuracies. Isolation improves the measurement accuracy by physically preventing ground loops. Ground loops—a common source of noise and error—are the results of a measurement system having multiple grounds at different potentials.
- **Common mode rejection:** With isolation, a DAQ device can measure small signals in the presence of large common mode voltages. Isolation increases the measurement system's ability to reject common mode voltages. The common mode voltage is the signal that is common to both the positive and negative inputs of the measurement device, but is not part of the signal to measure.

## Analog output terminals (VDAC0 through VDAC3)

The USB-2416-4AO has four 16-bit analog output channels with a  $\pm 10$  V output range.

Analog outputs can be updated at a maximum rate of 1 kS/s.

## Digital I/O

The USB-2416-4AO provides up to eight digital I/O lines with read/write rates of 500 port reads or single bit reads per second.

Digital input voltage ranges of 0 V to 15 V are permitted, with thresholds of 0.6 V (low) and 2.6 V (high). Each DIO channel is an *open-drain*, which, when used as an output, is capable of sinking up to 150 mA for direct drive applications. The maximum sink current is 150 mA per eight-channel bank, or if all eight channels are used, 18 mA (maximum) per channel.

Figure 13 is an example of a typical DIO connection. The figure represents connections for one channel. The other seven channels are connected in the same manner.

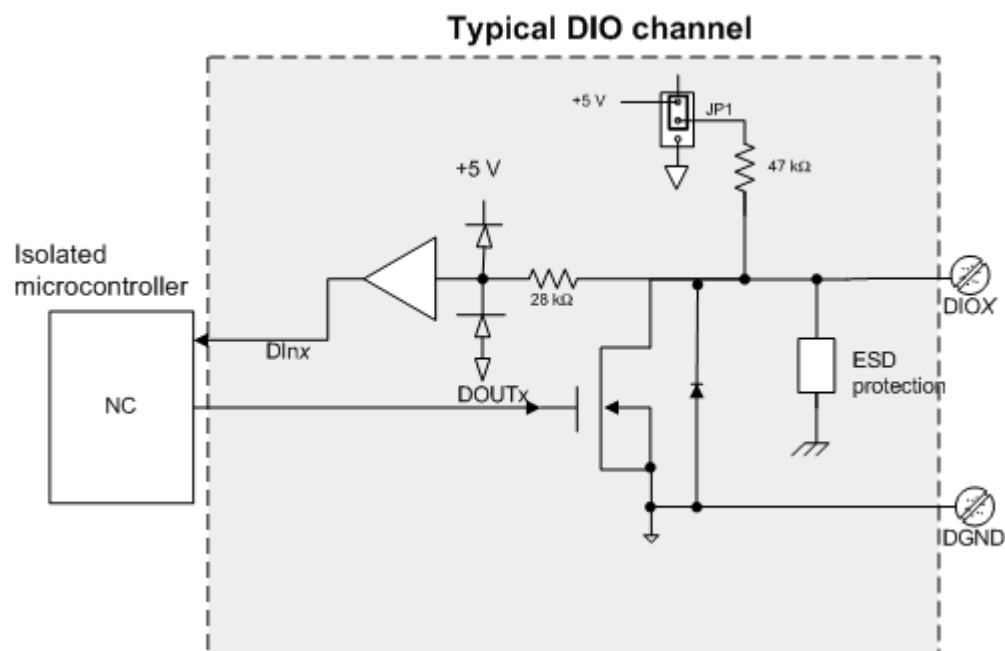


Figure 13. Digital output connection example

## Internal pull-up/pull-down capability

Each of the eight DIO bits on the USB-2416-4AO has a 47 k $\Omega$  pull-up/pull-down resistor. To configure these bits for the 0 V pull-down option, you must open the USB-2416-4AO case to access the three-pin jumper labeled JP1.

To open the case and set the JP1 jumper, do the following.

1. Turn over the USB-2416-4AO and rest it on its top on a flat, stable surface.
2. Remove the five screws shown in Figure 14 from the bottom of the module.
3. Holding both the top and bottom sections of the module, turn it over, rest it on the surface, and carefully remove the top portion of the case.

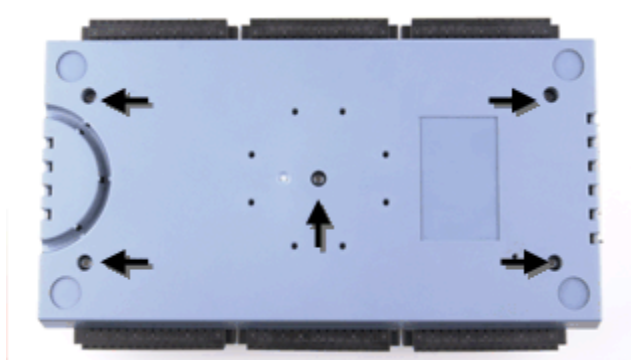


Figure 14. Location of screws connecting bottom and top sections of case

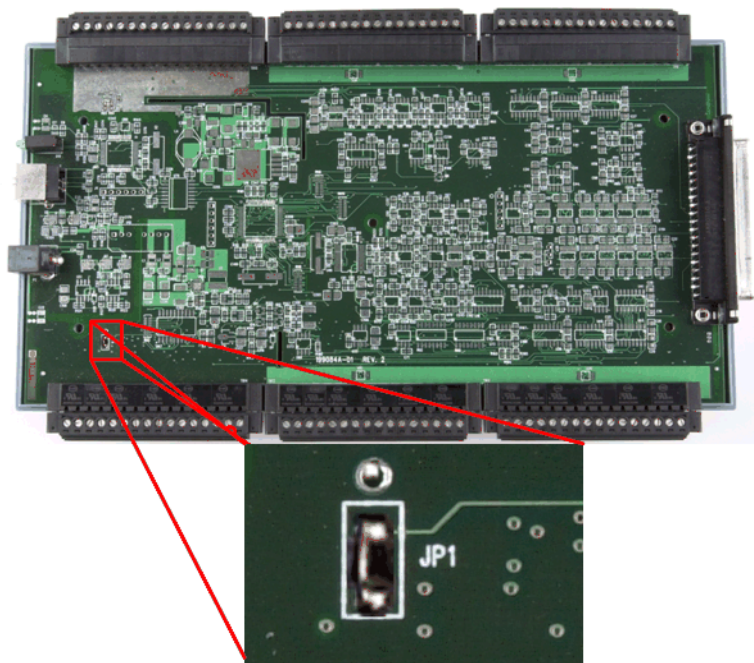


Figure 15. Location of JP1

The pull-up/pull-down voltage is common to all of the internal 47 k $\Omega$  resistors.

### External pull-up/pull-down capability

You can also place an external pull-up resistor on any of the DIO bits. This enables you to pull the DIO bit up to a voltage that exceeds the internal +5 V pull-up voltage.

When using external pull-up resistors, note the following:

- You should either remove the JP1 jumper or store it by attaching it to one of the three pins.
- When using external pull-up resistors, the internal resistors cause slight impedance shifts to digital lines in the "on" state as the number of lines in the "off" state changes.

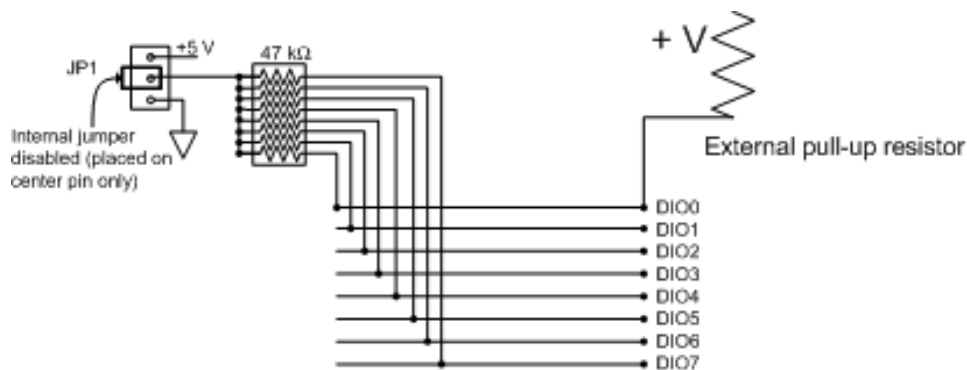


Figure 16. Digital I/O external resistor configuration

### Counter input terminals (CTR0, CTR1)

Two 32-bit event counters are built into the USB-2416-4AO. Each counter accepts frequency inputs up to 1 MHz.

Refer to the *Screw terminal pinout* diagrams starting on page 10 for the location of these pins. The internal counter increments when the TTL levels transition from low to high. The counter can count frequencies of up to 1 MHz.

## USB-2416-4AO mechanical drawings

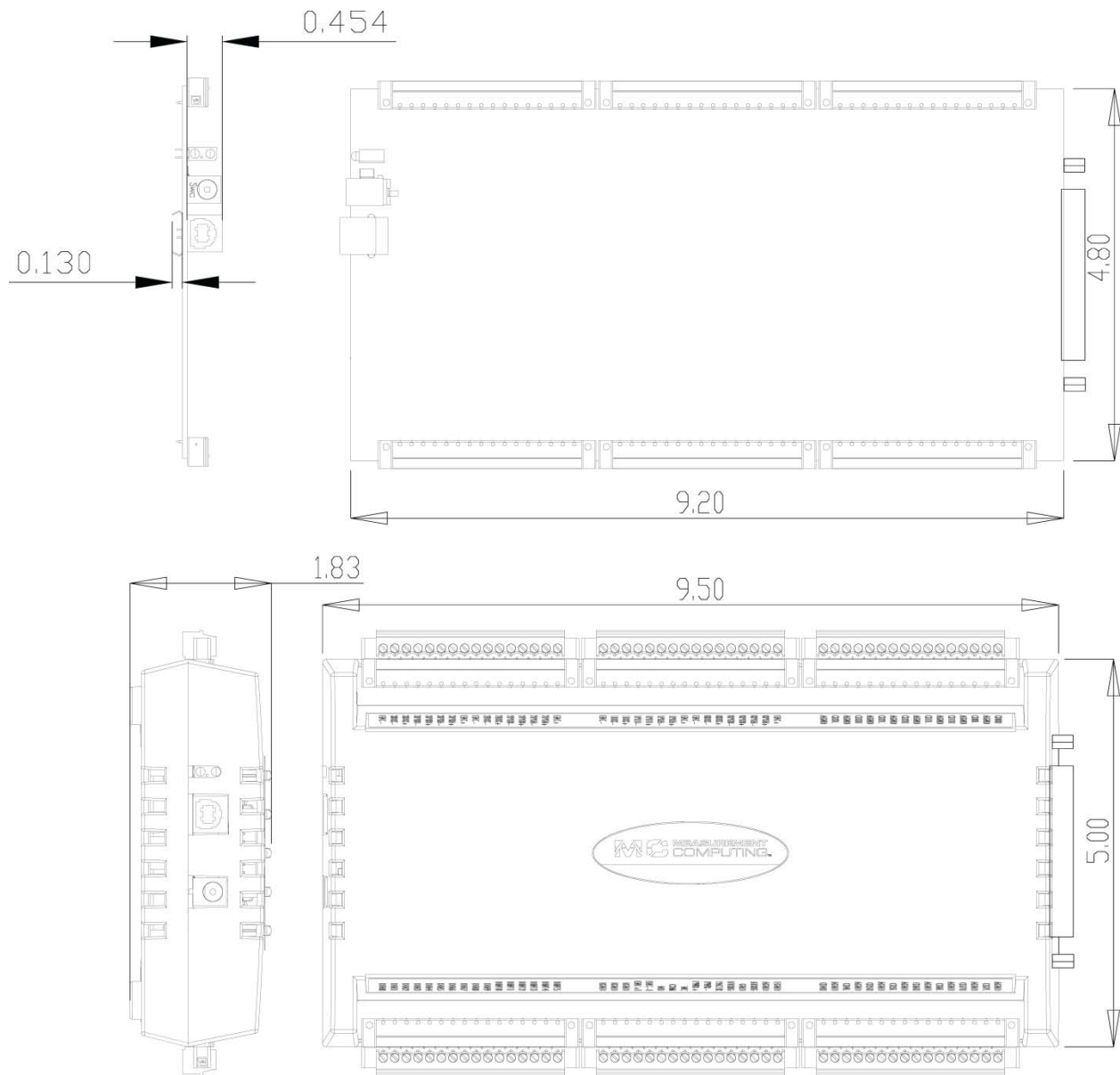


Figure 17. Circuit board (top) and enclosure dimensions

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## **Calibrating the USB-2416-4AO**

Measurement Computing calibrates the USB-2416-4AO using an NIST-traceable calibration method. This method stores a correction factor for each AIN range in non-volatile memory on the device at the time of calibration.

Allow a 45 minute warm-up period before calibrating the USB-2416-4AO.

### **Calibration methods**

#### **Factory calibration**

Measurement Computing's Manufacturing Test department performs the initial factory calibration. You can return the USB-2416-4AO once a year for a new factory calibration and calibration certificate.

#### **Self calibration**

Use InstaCal to calibrate the USB-2416-4AO whenever the ambient temperature changes by more than  $\pm 10$  °C from the last self-calibration

You can perform this procedure with thermocouple and voltage inputs connected to the input terminal blocks.

To calibrate the AOOUT circuits, disconnect the analog outputs at the terminal block pins to ensure optimum calibration results.

# Specifications

All specifications are subject to change without notice.

Typical for 25 °C unless otherwise specified.

All specifications apply to all temperature and voltage input channels unless otherwise specified.

Specifications in *italic text* are guaranteed by design.

## Analog input

Table 1. General analog input specifications

| Parameter                                      | Conditions                                                           | Specification                                                                                                                                                                                                                                                                   |
|------------------------------------------------|----------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| A/D converter type                             |                                                                      | ADS1256, 24-bit Sigma Delta                                                                                                                                                                                                                                                     |
| A/D data rates                                 |                                                                      | 3750 samples per second (S/s), 2000 S/s, 1000 S/s, 500 S/s, 100 S/s, 60 S/s, 50 S/s, 25 S/s, 10 S/s, 5 S/s, 2.5 S/s                                                                                                                                                             |
| Throughput                                     |                                                                      | <ul style="list-style-type: none"> <li>Single channel: 2.5 Hz to 1102.94 Hz, software selectable</li> <li>Multiple channels: 0.16 Hz to 1102.94 Hz, software selectable</li> </ul> See Table 18 and Table 19 for details.                                                       |
| Number of channels                             |                                                                      | Up to 32 channels individually software-configurable as single-ended or differential<br>Thermocouples require differential mode. For each channel configured as differential, you essentially lose one single-ended channel. You can add channels by connecting to an AI-EXP32. |
| <i>Input isolation</i>                         |                                                                      | <i>500 VDC minimum between field wiring and USB interface</i>                                                                                                                                                                                                                   |
| Channel configurations                         |                                                                      | Temperature sensor input, software programmable to match sensor type                                                                                                                                                                                                            |
|                                                |                                                                      | Voltage input                                                                                                                                                                                                                                                                   |
| Input voltage range                            | Thermocouple mode                                                    | $\pm 0.078125$ V                                                                                                                                                                                                                                                                |
|                                                | Voltage mode (Note 1)                                                | $\pm 20$ V, $\pm 10$ V, $\pm 5$ V, $\pm 2.5$ V, $\pm 1.25$ V, $\pm 0.625$ V, $\pm 0.3125$ V, $\pm 0.15625$ V, $\pm 0.078125$ V, software-configurable                                                                                                                           |
| <i>Absolute maximum input voltage</i>          | <i>CxH-CxL relative to GND</i>                                       | <ul style="list-style-type: none"> <li><math>\pm 30</math> V maximum (power on)</li> <li><math>\pm 10</math> V maximum (power off)</li> </ul>                                                                                                                                   |
|                                                |                                                                      |                                                                                                                                                                                                                                                                                 |
| <i>Input impedance</i>                         |                                                                      | <ul style="list-style-type: none"> <li>2 G<math>\Omega</math> (power on)</li> <li>390<math>\Omega</math> (power off)</li> </ul>                                                                                                                                                 |
|                                                |                                                                      |                                                                                                                                                                                                                                                                                 |
| <i>Input leakage current</i>                   |                                                                      | $\pm 10.6$ nA                                                                                                                                                                                                                                                                   |
| Input capacitance                              |                                                                      | 590 pF                                                                                                                                                                                                                                                                          |
| Maximum working voltage (signal + common mode) | Voltage mode: $\pm 20$ V range                                       | $\pm 20.01$ V maximum                                                                                                                                                                                                                                                           |
|                                                | Voltage mode: all other voltage input ranges                         | $\pm 10.25$ V maximum                                                                                                                                                                                                                                                           |
| <i>Common mode rejection ratio (Note 1)</i>    | <i>Thermocouple mode, (<math>f_{IN} = 60</math> Hz)</i>              | 110 dB                                                                                                                                                                                                                                                                          |
|                                                | <i>Voltage mode, (<math>f_{IN} = 60</math> Hz, all input ranges)</i> | 90 dB                                                                                                                                                                                                                                                                           |
| ADC resolution                                 |                                                                      | 24 bits                                                                                                                                                                                                                                                                         |
| Crosstalk                                      | Adjacent channels                                                    | 100 dB                                                                                                                                                                                                                                                                          |
| Input coupling                                 |                                                                      | DC                                                                                                                                                                                                                                                                              |
| Channel gain queue                             | Up to 64 elements                                                    | Software-configurable channel and range                                                                                                                                                                                                                                         |
| Warm-up time                                   |                                                                      | 45 minutes minimum                                                                                                                                                                                                                                                              |
| Open thermocouple detect                       |                                                                      | Automatically enabled when the channel is configured for a thermocouple sensor.                                                                                                                                                                                                 |
| <i>CJC sensor accuracy</i>                     | <i>15 °C to 35 °C</i>                                                | $\pm 0.15$ °C typical                                                                                                                                                                                                                                                           |
|                                                | <i>0 °C to 55 °C</i>                                                 | $\pm 0.5$ °C maximum                                                                                                                                                                                                                                                            |

**Note 1:** Placing a notch of the A/D digital filter at 60 Hz (setting A/D data rate = 60 S/s, 10 S/s, 5 S/s or 2.5 S/s) further improves the common mode rejection of this frequency.

## Channel configurations

When any item is changed, the firmware stores channel configurations in the EEPROM of the isolated microcontroller. An external application issues commands over the USB to make changes, and the configuration is made non-volatile through the use of the EEPROM.

When connecting differential voltage inputs to a floating voltage source, provide a DC return path from each voltage input to ground. To do this, connect a resistor from each input to a GND pin (pins 18, 36, 39, 42, 44, 46, 66, 81, 84). A value of approximately 100 k $\Omega$  can be used for most applications.

Leave unused input channels either floating or tied to GND (pins 18, 36, 39, 42, 44, 46, 66, 81, 84).

Source impedances should be kept as small as possible to avoid settling time and accuracy errors.

For each voltage/thermocouple channel configured as differential, you essentially lose one single-ended channel. You can add channels by connecting to an AI-EXP32.

Table 2. Channel configurations

| Channel | Category     | Specification                                                                                        |
|---------|--------------|------------------------------------------------------------------------------------------------------|
| CxH/CxL | Thermocouple | 16 differential channels                                                                             |
| CxH/CxL | Voltage      | 32 individually-configurable channels that can be configured as either single-ended or differential. |
| CxH/CxL | Voltage      |                                                                                                      |

## Compatible sensors

Table 3. Compatible sensor type specifications

| Parameter    | Conditions            |
|--------------|-----------------------|
| Thermocouple | J: -210 °C to 1200 °C |
|              | K: -270 °C to 1372 °C |
|              | R: -50 °C to 1768 °C  |
|              | S: -50 °C to 1768 °C  |
|              | T: -270 °C to 400 °C  |
|              | N: -270 °C to 1300 °C |
|              | E: -270 °C to 1000 °C |
|              | B: 0 °C to 1820 °C    |

## Accuracy

### Thermocouple measurement accuracy

Thermocouple measurement accuracy specifications include polynomial linearization error, cold-junction compensation measurement error, and system noise. These specs are for one year, or 3000 operating hours, whichever comes first.

There is a CJC sensor for each terminal block of the module. The accuracy listed below assumes the screw terminals are at the same temperature as the CJC sensor.

The accuracy errors shown do not include the inherent accuracy error of the thermocouple sensor itself. Contact your thermocouple supplier for details on the actual thermocouple sensor accuracy limitations.

Connect thermocouples to the USB-2416-4AO such that they are floating with respect to GND (pins 18, 36, 39, 42, 44, 46, 66, 81, 84, 93, and 94).

When configuring thermocouple sensors, keep any stray capacitance relative to GND (pins 18, 36, 39, 42, 44, 46, 66, 81, 84) as small as possible to avoid settling time and accuracy errors.

The USB-2416-4AO GND and DGND pins are isolated from earth ground. You can connect thermocouple sensors to voltages referenced to earth ground as long as isolation between the GND/DGND pins and earth ground is maintained.

Table 4. J type thermocouple accuracy specifications, including CJC measurement error.  
All specifications are ( $\pm$ ).

| A/D data rate | Sensor temperature range | Accuracy error maximum   | Accuracy error typical   | Tempco ( $^{\circ}\text{C}/^{\circ}\text{C}$ ) |
|---------------|--------------------------|--------------------------|--------------------------|------------------------------------------------|
| 3750 S/s      | -210 $^{\circ}\text{C}$  | 2.572 $^{\circ}\text{C}$ | 1.416 $^{\circ}\text{C}$ | 0.022                                          |
|               | 0 $^{\circ}\text{C}$     | 0.935 $^{\circ}\text{C}$ | 0.469 $^{\circ}\text{C}$ |                                                |
|               | 1200 $^{\circ}\text{C}$  | 1.869 $^{\circ}\text{C}$ | 1.456 $^{\circ}\text{C}$ |                                                |
| 2000 S/s      | -210 $^{\circ}\text{C}$  | 2.572 $^{\circ}\text{C}$ | 1.416 $^{\circ}\text{C}$ | 0.022                                          |
|               | 0 $^{\circ}\text{C}$     | 0.935 $^{\circ}\text{C}$ | 0.469 $^{\circ}\text{C}$ |                                                |
|               | 1200 $^{\circ}\text{C}$  | 1.869 $^{\circ}\text{C}$ | 1.456 $^{\circ}\text{C}$ |                                                |
| 1000 S/s      | -210 $^{\circ}\text{C}$  | 2.572 $^{\circ}\text{C}$ | 1.416 $^{\circ}\text{C}$ | 0.022                                          |
|               | 0 $^{\circ}\text{C}$     | 0.935 $^{\circ}\text{C}$ | 0.469 $^{\circ}\text{C}$ |                                                |
|               | 1200 $^{\circ}\text{C}$  | 1.869 $^{\circ}\text{C}$ | 1.456 $^{\circ}\text{C}$ |                                                |
| 500 S/s       | -210 $^{\circ}\text{C}$  | 2.442 $^{\circ}\text{C}$ | 1.334 $^{\circ}\text{C}$ | 0.022                                          |
|               | 0 $^{\circ}\text{C}$     | 0.881 $^{\circ}\text{C}$ | 0.415 $^{\circ}\text{C}$ |                                                |
|               | 1200 $^{\circ}\text{C}$  | 1.821 $^{\circ}\text{C}$ | 1.408 $^{\circ}\text{C}$ |                                                |
| 100 S/s       | -210 $^{\circ}\text{C}$  | 2.442 $^{\circ}\text{C}$ | 1.334 $^{\circ}\text{C}$ | 0.022                                          |
|               | 0 $^{\circ}\text{C}$     | 0.881 $^{\circ}\text{C}$ | 0.415 $^{\circ}\text{C}$ |                                                |
|               | 1200 $^{\circ}\text{C}$  | 1.821 $^{\circ}\text{C}$ | 1.408 $^{\circ}\text{C}$ |                                                |
| 60 S/s        | -210 $^{\circ}\text{C}$  | 2.442 $^{\circ}\text{C}$ | 1.334 $^{\circ}\text{C}$ | 0.022                                          |
|               | 0 $^{\circ}\text{C}$     | 0.881 $^{\circ}\text{C}$ | 0.415 $^{\circ}\text{C}$ |                                                |
|               | 1200 $^{\circ}\text{C}$  | 1.821 $^{\circ}\text{C}$ | 1.408 $^{\circ}\text{C}$ |                                                |
| 50 S/s        | -210 $^{\circ}\text{C}$  | 2.442 $^{\circ}\text{C}$ | 1.334 $^{\circ}\text{C}$ | 0.022                                          |
|               | 0 $^{\circ}\text{C}$     | 0.881 $^{\circ}\text{C}$ | 0.415 $^{\circ}\text{C}$ |                                                |
|               | 1200 $^{\circ}\text{C}$  | 1.821 $^{\circ}\text{C}$ | 1.408 $^{\circ}\text{C}$ |                                                |
| 25 S/s        | -210 $^{\circ}\text{C}$  | 2.442 $^{\circ}\text{C}$ | 1.334 $^{\circ}\text{C}$ | 0.022                                          |
|               | 0 $^{\circ}\text{C}$     | 0.881 $^{\circ}\text{C}$ | 0.415 $^{\circ}\text{C}$ |                                                |
|               | 1200 $^{\circ}\text{C}$  | 1.821 $^{\circ}\text{C}$ | 1.408 $^{\circ}\text{C}$ |                                                |
| 10 S/s        | -210 $^{\circ}\text{C}$  | 2.442 $^{\circ}\text{C}$ | 1.334 $^{\circ}\text{C}$ | 0.022                                          |
|               | 0 $^{\circ}\text{C}$     | 0.881 $^{\circ}\text{C}$ | 0.415 $^{\circ}\text{C}$ |                                                |
|               | 1200 $^{\circ}\text{C}$  | 1.821 $^{\circ}\text{C}$ | 1.408 $^{\circ}\text{C}$ |                                                |
| 5 S/s         | -210 $^{\circ}\text{C}$  | 2.442 $^{\circ}\text{C}$ | 1.334 $^{\circ}\text{C}$ | 0.022                                          |
|               | 0 $^{\circ}\text{C}$     | 0.881 $^{\circ}\text{C}$ | 0.415 $^{\circ}\text{C}$ |                                                |
|               | 1200 $^{\circ}\text{C}$  | 1.821 $^{\circ}\text{C}$ | 1.408 $^{\circ}\text{C}$ |                                                |
| 2.5 S/s       | -210 $^{\circ}\text{C}$  | 2.442 $^{\circ}\text{C}$ | 1.334 $^{\circ}\text{C}$ | 0.022                                          |
|               | 0 $^{\circ}\text{C}$     | 0.881 $^{\circ}\text{C}$ | 0.415 $^{\circ}\text{C}$ |                                                |
|               | 1200 $^{\circ}\text{C}$  | 1.821 $^{\circ}\text{C}$ | 1.408 $^{\circ}\text{C}$ |                                                |

To achieve the thermocouple accuracies listed above, the USB-2416-4AO should be warmed up for 45 minutes after the initial power on. The accuracies listed above are only guaranteed if the USB-2416-4AO is housed in its plastic enclosure.

Table 5. K type thermocouple accuracy specifications, including CJC measurement error.  
All specifications are ( $\pm$ ).

| A/D data rate | Sensor temperature range | Accuracy error maximum   | Accuracy error typical   | Tempco ( $^{\circ}\text{C}/^{\circ}\text{C}$ ) |
|---------------|--------------------------|--------------------------|--------------------------|------------------------------------------------|
| 3750 S/s      | -210 $^{\circ}\text{C}$  | 2.917 $^{\circ}\text{C}$ | 1.699 $^{\circ}\text{C}$ | 0.029                                          |
|               | 0 $^{\circ}\text{C}$     | 1.017 $^{\circ}\text{C}$ | 0.526 $^{\circ}\text{C}$ |                                                |
|               | 1372 $^{\circ}\text{C}$  | 2.478 $^{\circ}\text{C}$ | 2.022 $^{\circ}\text{C}$ |                                                |
| 2000 S/s      | -210 $^{\circ}\text{C}$  | 2.917 $^{\circ}\text{C}$ | 1.699 $^{\circ}\text{C}$ | 0.029                                          |
|               | 0 $^{\circ}\text{C}$     | 1.017 $^{\circ}\text{C}$ | 0.526 $^{\circ}\text{C}$ |                                                |
|               | 1372 $^{\circ}\text{C}$  | 2.478 $^{\circ}\text{C}$ | 2.022 $^{\circ}\text{C}$ |                                                |
| 1000 S/s      | -210 $^{\circ}\text{C}$  | 2.917 $^{\circ}\text{C}$ | 1.699 $^{\circ}\text{C}$ | 0.029                                          |
|               | 0 $^{\circ}\text{C}$     | 1.017 $^{\circ}\text{C}$ | 0.526 $^{\circ}\text{C}$ |                                                |
|               | 1372 $^{\circ}\text{C}$  | 2.478 $^{\circ}\text{C}$ | 2.022 $^{\circ}\text{C}$ |                                                |
| 500 S/s       | -210 $^{\circ}\text{C}$  | 2.735 $^{\circ}\text{C}$ | 1.524 $^{\circ}\text{C}$ | 0.029                                          |
|               | 0 $^{\circ}\text{C}$     | 0.948 $^{\circ}\text{C}$ | 0.457 $^{\circ}\text{C}$ |                                                |
|               | 1372 $^{\circ}\text{C}$  | 2.396 $^{\circ}\text{C}$ | 1.941 $^{\circ}\text{C}$ |                                                |
| 100 S/s       | -210 $^{\circ}\text{C}$  | 2.735 $^{\circ}\text{C}$ | 1.524 $^{\circ}\text{C}$ | 0.029                                          |
|               | 0 $^{\circ}\text{C}$     | 0.948 $^{\circ}\text{C}$ | 0.457 $^{\circ}\text{C}$ |                                                |
|               | 1372 $^{\circ}\text{C}$  | 2.396 $^{\circ}\text{C}$ | 1.941 $^{\circ}\text{C}$ |                                                |
| 60 S/s        | -210 $^{\circ}\text{C}$  | 2.735 $^{\circ}\text{C}$ | 1.524 $^{\circ}\text{C}$ | 0.029                                          |
|               | 0 $^{\circ}\text{C}$     | 0.948 $^{\circ}\text{C}$ | 0.457 $^{\circ}\text{C}$ |                                                |
|               | 1372 $^{\circ}\text{C}$  | 2.396 $^{\circ}\text{C}$ | 1.941 $^{\circ}\text{C}$ |                                                |
| 50 S/s        | -210 $^{\circ}\text{C}$  | 2.735 $^{\circ}\text{C}$ | 1.524 $^{\circ}\text{C}$ | 0.029                                          |
|               | 0 $^{\circ}\text{C}$     | 0.948 $^{\circ}\text{C}$ | 0.457 $^{\circ}\text{C}$ |                                                |
|               | 1372 $^{\circ}\text{C}$  | 2.396 $^{\circ}\text{C}$ | 1.941 $^{\circ}\text{C}$ |                                                |
| 25 S/s        | -210 $^{\circ}\text{C}$  | 2.735 $^{\circ}\text{C}$ | 1.524 $^{\circ}\text{C}$ | 0.029                                          |
|               | 0 $^{\circ}\text{C}$     | 0.948 $^{\circ}\text{C}$ | 0.457 $^{\circ}\text{C}$ |                                                |
|               | 1372 $^{\circ}\text{C}$  | 2.396 $^{\circ}\text{C}$ | 1.941 $^{\circ}\text{C}$ |                                                |
| 10 S/s        | -210 $^{\circ}\text{C}$  | 2.735 $^{\circ}\text{C}$ | 1.524 $^{\circ}\text{C}$ | 0.029                                          |
|               | 0 $^{\circ}\text{C}$     | 0.948 $^{\circ}\text{C}$ | 0.457 $^{\circ}\text{C}$ |                                                |
|               | 1372 $^{\circ}\text{C}$  | 2.396 $^{\circ}\text{C}$ | 1.941 $^{\circ}\text{C}$ |                                                |
| 5 S/s         | -210 $^{\circ}\text{C}$  | 2.735 $^{\circ}\text{C}$ | 1.524 $^{\circ}\text{C}$ | 0.029                                          |
|               | 0 $^{\circ}\text{C}$     | 0.948 $^{\circ}\text{C}$ | 0.457 $^{\circ}\text{C}$ |                                                |
|               | 1372 $^{\circ}\text{C}$  | 2.396 $^{\circ}\text{C}$ | 1.941 $^{\circ}\text{C}$ |                                                |
| 2.5 S/s       | -210 $^{\circ}\text{C}$  | 2.735 $^{\circ}\text{C}$ | 1.524 $^{\circ}\text{C}$ | 0.029                                          |
|               | 0 $^{\circ}\text{C}$     | 0.948 $^{\circ}\text{C}$ | 0.457 $^{\circ}\text{C}$ |                                                |
|               | 1372 $^{\circ}\text{C}$  | 2.396 $^{\circ}\text{C}$ | 1.941 $^{\circ}\text{C}$ |                                                |

To achieve the thermocouple accuracies listed above, the USB-2416-4AO should be warmed up for 45 minutes after the initial power on. The accuracies listed above are only guaranteed if the USB-2416-4AO is housed in its plastic enclosure.

Table 6. N type thermocouple accuracy specifications, including CJC measurement error.  
All specifications are ( $\pm$ ).

| A/D data rate | Sensor temperature range | Accuracy error maximum   | Accuracy error typical   | Tempco ( $^{\circ}\text{C}/^{\circ}\text{C}$ ) |
|---------------|--------------------------|--------------------------|--------------------------|------------------------------------------------|
| 3750 S/s      | -200 $^{\circ}\text{C}$  | 3.480 $^{\circ}\text{C}$ | 2.030 $^{\circ}\text{C}$ | 0.029                                          |
|               | 0 $^{\circ}\text{C}$     | 1.201 $^{\circ}\text{C}$ | 0.659 $^{\circ}\text{C}$ |                                                |
|               | 1300 $^{\circ}\text{C}$  | 1.991 $^{\circ}\text{C}$ | 1.600 $^{\circ}\text{C}$ |                                                |
| 2000 S/s      | -200 $^{\circ}\text{C}$  | 3.480 $^{\circ}\text{C}$ | 2.030 $^{\circ}\text{C}$ | 0.029                                          |
|               | 0 $^{\circ}\text{C}$     | 1.201 $^{\circ}\text{C}$ | 0.659 $^{\circ}\text{C}$ |                                                |
|               | 1300 $^{\circ}\text{C}$  | 1.991 $^{\circ}\text{C}$ | 1.600 $^{\circ}\text{C}$ |                                                |
| 1000 S/s      | -200 $^{\circ}\text{C}$  | 3.480 $^{\circ}\text{C}$ | 2.030 $^{\circ}\text{C}$ | 0.029                                          |
|               | 0 $^{\circ}\text{C}$     | 1.201 $^{\circ}\text{C}$ | 0.659 $^{\circ}\text{C}$ |                                                |
|               | 1300 $^{\circ}\text{C}$  | 1.991 $^{\circ}\text{C}$ | 1.600 $^{\circ}\text{C}$ |                                                |
| 500 S/s       | -200 $^{\circ}\text{C}$  | 3.196 $^{\circ}\text{C}$ | 1.750 $^{\circ}\text{C}$ | 0.029                                          |
|               | 0 $^{\circ}\text{C}$     | 1.096 $^{\circ}\text{C}$ | 0.553 $^{\circ}\text{C}$ |                                                |
|               | 1300 $^{\circ}\text{C}$  | 1.915 $^{\circ}\text{C}$ | 1.524 $^{\circ}\text{C}$ |                                                |
| 100 S/s       | -200 $^{\circ}\text{C}$  | 3.196 $^{\circ}\text{C}$ | 1.750 $^{\circ}\text{C}$ | 0.029                                          |
|               | 0 $^{\circ}\text{C}$     | 1.096 $^{\circ}\text{C}$ | 0.553 $^{\circ}\text{C}$ |                                                |
|               | 1300 $^{\circ}\text{C}$  | 1.915 $^{\circ}\text{C}$ | 1.524 $^{\circ}\text{C}$ |                                                |
| 60 S/s        | -200 $^{\circ}\text{C}$  | 3.196 $^{\circ}\text{C}$ | 1.750 $^{\circ}\text{C}$ | 0.029                                          |
|               | 0 $^{\circ}\text{C}$     | 1.096 $^{\circ}\text{C}$ | 0.553 $^{\circ}\text{C}$ |                                                |
|               | 1300 $^{\circ}\text{C}$  | 1.915 $^{\circ}\text{C}$ | 1.524 $^{\circ}\text{C}$ |                                                |
| 50 S/s        | -200 $^{\circ}\text{C}$  | 3.196 $^{\circ}\text{C}$ | 1.750 $^{\circ}\text{C}$ | 0.029                                          |
|               | 0 $^{\circ}\text{C}$     | 1.096 $^{\circ}\text{C}$ | 0.553 $^{\circ}\text{C}$ |                                                |
|               | 1300 $^{\circ}\text{C}$  | 1.915 $^{\circ}\text{C}$ | 1.524 $^{\circ}\text{C}$ |                                                |
| 25 S/s        | -200 $^{\circ}\text{C}$  | 3.196 $^{\circ}\text{C}$ | 1.750 $^{\circ}\text{C}$ | 0.029                                          |
|               | 0 $^{\circ}\text{C}$     | 1.096 $^{\circ}\text{C}$ | 0.553 $^{\circ}\text{C}$ |                                                |
|               | 1300 $^{\circ}\text{C}$  | 1.915 $^{\circ}\text{C}$ | 1.524 $^{\circ}\text{C}$ |                                                |
| 10 S/s        | -200 $^{\circ}\text{C}$  | 3.196 $^{\circ}\text{C}$ | 1.750 $^{\circ}\text{C}$ | 0.029                                          |
|               | 0 $^{\circ}\text{C}$     | 1.096 $^{\circ}\text{C}$ | 0.553 $^{\circ}\text{C}$ |                                                |
|               | 1300 $^{\circ}\text{C}$  | 1.915 $^{\circ}\text{C}$ | 1.524 $^{\circ}\text{C}$ |                                                |
| 5 S/s         | -200 $^{\circ}\text{C}$  | 3.196 $^{\circ}\text{C}$ | 1.750 $^{\circ}\text{C}$ | 0.029                                          |
|               | 0 $^{\circ}\text{C}$     | 1.096 $^{\circ}\text{C}$ | 0.553 $^{\circ}\text{C}$ |                                                |
|               | 1300 $^{\circ}\text{C}$  | 1.915 $^{\circ}\text{C}$ | 1.524 $^{\circ}\text{C}$ |                                                |
| 2.5 S/s       | -200 $^{\circ}\text{C}$  | 3.196 $^{\circ}\text{C}$ | 1.750 $^{\circ}\text{C}$ | 0.029                                          |
|               | 0 $^{\circ}\text{C}$     | 1.096 $^{\circ}\text{C}$ | 0.553 $^{\circ}\text{C}$ |                                                |
|               | 1300 $^{\circ}\text{C}$  | 1.915 $^{\circ}\text{C}$ | 1.524 $^{\circ}\text{C}$ |                                                |

To achieve the thermocouple accuracies listed above, the USB-2416-4AO should be warmed up for 45 minutes after the initial power on. The accuracies listed above are only guaranteed if the USB-2416-4AO is housed in its plastic enclosure.

Table 7. R type thermocouple accuracy specifications, including CJC measurement error.  
All specifications are ( $\pm$ ).

| A/D data rate | Sensor temperature range | Accuracy error maximum   | Accuracy error typical   | Tempco ( $^{\circ}\text{C}/^{\circ}\text{C}$ ) |
|---------------|--------------------------|--------------------------|--------------------------|------------------------------------------------|
| 3750 S/s      | -50 $^{\circ}\text{C}$   | 4.826 $^{\circ}\text{C}$ | 3.133 $^{\circ}\text{C}$ | 0.082                                          |
|               | 250 $^{\circ}\text{C}$   | 2.117 $^{\circ}\text{C}$ | 1.424 $^{\circ}\text{C}$ |                                                |
|               | 1768 $^{\circ}\text{C}$  | 2.842 $^{\circ}\text{C}$ | 2.347 $^{\circ}\text{C}$ |                                                |
| 2000 S/s      | -50 $^{\circ}\text{C}$   | 4.826 $^{\circ}\text{C}$ | 3.133 $^{\circ}\text{C}$ | 0.082                                          |
|               | 250 $^{\circ}\text{C}$   | 2.117 $^{\circ}\text{C}$ | 1.424 $^{\circ}\text{C}$ |                                                |
|               | 1768 $^{\circ}\text{C}$  | 2.842 $^{\circ}\text{C}$ | 2.347 $^{\circ}\text{C}$ |                                                |
| 1000 S/s      | -50 $^{\circ}\text{C}$   | 4.826 $^{\circ}\text{C}$ | 3.133 $^{\circ}\text{C}$ | 0.082                                          |
|               | 250 $^{\circ}\text{C}$   | 2.117 $^{\circ}\text{C}$ | 1.424 $^{\circ}\text{C}$ |                                                |
|               | 1768 $^{\circ}\text{C}$  | 2.842 $^{\circ}\text{C}$ | 2.347 $^{\circ}\text{C}$ |                                                |
| 500 S/s       | -50 $^{\circ}\text{C}$   | 4.065 $^{\circ}\text{C}$ | 2.379 $^{\circ}\text{C}$ | 0.082                                          |
|               | 250 $^{\circ}\text{C}$   | 1.805 $^{\circ}\text{C}$ | 1.113 $^{\circ}\text{C}$ |                                                |
|               | 1768 $^{\circ}\text{C}$  | 2.619 $^{\circ}\text{C}$ | 2.123 $^{\circ}\text{C}$ |                                                |
| 100 S/s       | -50 $^{\circ}\text{C}$   | 4.065 $^{\circ}\text{C}$ | 2.379 $^{\circ}\text{C}$ | 0.082                                          |
|               | 250 $^{\circ}\text{C}$   | 1.805 $^{\circ}\text{C}$ | 1.113 $^{\circ}\text{C}$ |                                                |
|               | 1768 $^{\circ}\text{C}$  | 2.619 $^{\circ}\text{C}$ | 2.123 $^{\circ}\text{C}$ |                                                |
| 60 S/s        | -50 $^{\circ}\text{C}$   | 4.065 $^{\circ}\text{C}$ | 2.379 $^{\circ}\text{C}$ | 0.082                                          |
|               | 250 $^{\circ}\text{C}$   | 1.805 $^{\circ}\text{C}$ | 1.113 $^{\circ}\text{C}$ |                                                |
|               | 1768 $^{\circ}\text{C}$  | 2.619 $^{\circ}\text{C}$ | 2.123 $^{\circ}\text{C}$ |                                                |
| 50 S/s        | -50 $^{\circ}\text{C}$   | 4.065 $^{\circ}\text{C}$ | 2.379 $^{\circ}\text{C}$ | 0.082                                          |
|               | 250 $^{\circ}\text{C}$   | 1.805 $^{\circ}\text{C}$ | 1.113 $^{\circ}\text{C}$ |                                                |
|               | 1768 $^{\circ}\text{C}$  | 2.619 $^{\circ}\text{C}$ | 2.123 $^{\circ}\text{C}$ |                                                |
| 25 S/s        | -50 $^{\circ}\text{C}$   | 4.065 $^{\circ}\text{C}$ | 2.379 $^{\circ}\text{C}$ | 0.082                                          |
|               | 250 $^{\circ}\text{C}$   | 1.805 $^{\circ}\text{C}$ | 1.113 $^{\circ}\text{C}$ |                                                |
|               | 1768 $^{\circ}\text{C}$  | 2.619 $^{\circ}\text{C}$ | 2.123 $^{\circ}\text{C}$ |                                                |
| 10 S/s        | -50 $^{\circ}\text{C}$   | 4.065 $^{\circ}\text{C}$ | 2.379 $^{\circ}\text{C}$ | 0.082                                          |
|               | 250 $^{\circ}\text{C}$   | 1.805 $^{\circ}\text{C}$ | 1.113 $^{\circ}\text{C}$ |                                                |
|               | 1768 $^{\circ}\text{C}$  | 2.619 $^{\circ}\text{C}$ | 2.123 $^{\circ}\text{C}$ |                                                |
| 5 S/s         | -50 $^{\circ}\text{C}$   | 4.065 $^{\circ}\text{C}$ | 2.379 $^{\circ}\text{C}$ | 0.082                                          |
|               | 250 $^{\circ}\text{C}$   | 1.805 $^{\circ}\text{C}$ | 1.113 $^{\circ}\text{C}$ |                                                |
|               | 1768 $^{\circ}\text{C}$  | 2.619 $^{\circ}\text{C}$ | 2.123 $^{\circ}\text{C}$ |                                                |
| 2.5 S/s       | -50 $^{\circ}\text{C}$   | 4.065 $^{\circ}\text{C}$ | 2.379 $^{\circ}\text{C}$ | 0.082                                          |
|               | 250 $^{\circ}\text{C}$   | 1.805 $^{\circ}\text{C}$ | 1.113 $^{\circ}\text{C}$ |                                                |
|               | 1768 $^{\circ}\text{C}$  | 2.619 $^{\circ}\text{C}$ | 2.123 $^{\circ}\text{C}$ |                                                |

To achieve the thermocouple accuracies listed above, the USB-2416-4AO should be warmed up for 45 minutes after the initial power on. The accuracies listed above are only guaranteed if the USB-2416-4AO is housed in its plastic enclosure.

Table 8. S type thermocouple accuracy specifications, including CJC measurement error.  
All specifications are ( $\pm$ ).

| A/D data rate | Sensor temperature range | Accuracy error maximum   | Accuracy error typical   | Tempco ( $^{\circ}\text{C}/^{\circ}\text{C}$ ) |
|---------------|--------------------------|--------------------------|--------------------------|------------------------------------------------|
| 3750 S/s      | -50 $^{\circ}\text{C}$   | 4.510 $^{\circ}\text{C}$ | 2.930 $^{\circ}\text{C}$ | 0.088                                          |
|               | 250 $^{\circ}\text{C}$   | 2.165 $^{\circ}\text{C}$ | 1.468 $^{\circ}\text{C}$ |                                                |
|               | 1768 $^{\circ}\text{C}$  | 3.187 $^{\circ}\text{C}$ | 2.597 $^{\circ}\text{C}$ |                                                |
| 2000 S/s      | -50 $^{\circ}\text{C}$   | 4.510 $^{\circ}\text{C}$ | 2.930 $^{\circ}\text{C}$ | 0.088                                          |
|               | 250 $^{\circ}\text{C}$   | 2.165 $^{\circ}\text{C}$ | 1.468 $^{\circ}\text{C}$ |                                                |
|               | 1768 $^{\circ}\text{C}$  | 3.187 $^{\circ}\text{C}$ | 2.597 $^{\circ}\text{C}$ |                                                |
| 1000 S/s      | -50 $^{\circ}\text{C}$   | 4.510 $^{\circ}\text{C}$ | 2.930 $^{\circ}\text{C}$ | 0.088                                          |
|               | 250 $^{\circ}\text{C}$   | 2.165 $^{\circ}\text{C}$ | 1.468 $^{\circ}\text{C}$ |                                                |
|               | 1768 $^{\circ}\text{C}$  | 3.187 $^{\circ}\text{C}$ | 2.597 $^{\circ}\text{C}$ |                                                |
| 500 S/s       | -50 $^{\circ}\text{C}$   | 3.798 $^{\circ}\text{C}$ | 2.226 $^{\circ}\text{C}$ | 0.088                                          |
|               | 250 $^{\circ}\text{C}$   | 1.853 $^{\circ}\text{C}$ | 1.156 $^{\circ}\text{C}$ |                                                |
|               | 1768 $^{\circ}\text{C}$  | 2.922 $^{\circ}\text{C}$ | 2.332 $^{\circ}\text{C}$ |                                                |
| 100 S/s       | -50 $^{\circ}\text{C}$   | 3.798 $^{\circ}\text{C}$ | 2.226 $^{\circ}\text{C}$ | 0.088                                          |
|               | 250 $^{\circ}\text{C}$   | 1.853 $^{\circ}\text{C}$ | 1.156 $^{\circ}\text{C}$ |                                                |
|               | 1768 $^{\circ}\text{C}$  | 2.922 $^{\circ}\text{C}$ | 2.332 $^{\circ}\text{C}$ |                                                |
| 60 S/s        | -50 $^{\circ}\text{C}$   | 3.798 $^{\circ}\text{C}$ | 2.226 $^{\circ}\text{C}$ | 0.088                                          |
|               | 250 $^{\circ}\text{C}$   | 1.853 $^{\circ}\text{C}$ | 1.156 $^{\circ}\text{C}$ |                                                |
|               | 1768 $^{\circ}\text{C}$  | 2.922 $^{\circ}\text{C}$ | 2.332 $^{\circ}\text{C}$ |                                                |
| 50 S/s        | -50 $^{\circ}\text{C}$   | 3.798 $^{\circ}\text{C}$ | 2.226 $^{\circ}\text{C}$ | 0.088                                          |
|               | 250 $^{\circ}\text{C}$   | 1.853 $^{\circ}\text{C}$ | 1.156 $^{\circ}\text{C}$ |                                                |
|               | 1768 $^{\circ}\text{C}$  | 2.922 $^{\circ}\text{C}$ | 2.332 $^{\circ}\text{C}$ |                                                |
| 25 S/s        | -50 $^{\circ}\text{C}$   | 3.798 $^{\circ}\text{C}$ | 2.226 $^{\circ}\text{C}$ | 0.088                                          |
|               | 250 $^{\circ}\text{C}$   | 1.853 $^{\circ}\text{C}$ | 1.156 $^{\circ}\text{C}$ |                                                |
|               | 1768 $^{\circ}\text{C}$  | 2.922 $^{\circ}\text{C}$ | 2.332 $^{\circ}\text{C}$ |                                                |
| 10 S/s        | -50 $^{\circ}\text{C}$   | 3.798 $^{\circ}\text{C}$ | 2.226 $^{\circ}\text{C}$ | 0.088                                          |
|               | 250 $^{\circ}\text{C}$   | 1.853 $^{\circ}\text{C}$ | 1.156 $^{\circ}\text{C}$ |                                                |
|               | 1768 $^{\circ}\text{C}$  | 2.922 $^{\circ}\text{C}$ | 2.332 $^{\circ}\text{C}$ |                                                |
| 5 S/s         | -50 $^{\circ}\text{C}$   | 3.798 $^{\circ}\text{C}$ | 2.226 $^{\circ}\text{C}$ | 0.088                                          |
|               | 250 $^{\circ}\text{C}$   | 1.853 $^{\circ}\text{C}$ | 1.156 $^{\circ}\text{C}$ |                                                |
|               | 1768 $^{\circ}\text{C}$  | 2.922 $^{\circ}\text{C}$ | 2.332 $^{\circ}\text{C}$ |                                                |
| 2.5 S/s       | -50 $^{\circ}\text{C}$   | 3.798 $^{\circ}\text{C}$ | 2.226 $^{\circ}\text{C}$ | 0.088                                          |
|               | 250 $^{\circ}\text{C}$   | 1.853 $^{\circ}\text{C}$ | 1.156 $^{\circ}\text{C}$ |                                                |
|               | 1768 $^{\circ}\text{C}$  | 2.922 $^{\circ}\text{C}$ | 2.332 $^{\circ}\text{C}$ |                                                |

To achieve the thermocouple accuracies listed above, the USB-2416-4AO should be warmed up for 45 minutes after the initial power on. The accuracies listed above are only guaranteed if the USB-2416-4AO is housed in its plastic enclosure.

Table 9. B type thermocouple accuracy specifications, including CJC measurement error.  
All specifications are ( $\pm$ ).

| A/D data rate | Sensor temperature range | Accuracy error maximum   | Accuracy error typical   | Tempco ( $^{\circ}\text{C}/^{\circ}\text{C}$ ) |
|---------------|--------------------------|--------------------------|--------------------------|------------------------------------------------|
| 3750 S/s      | 250 $^{\circ}\text{C}$   | 5.489 $^{\circ}\text{C}$ | 3.956 $^{\circ}\text{C}$ | 0.14                                           |
|               | 700 $^{\circ}\text{C}$   | 2.283 $^{\circ}\text{C}$ | 1.743 $^{\circ}\text{C}$ |                                                |
|               | 1820 $^{\circ}\text{C}$  | 2.202 $^{\circ}\text{C}$ | 1.842 $^{\circ}\text{C}$ |                                                |
| 2000 S/s      | 250 $^{\circ}\text{C}$   | 5.489 $^{\circ}\text{C}$ | 3.956 $^{\circ}\text{C}$ | 0.14                                           |
|               | 700 $^{\circ}\text{C}$   | 2.283 $^{\circ}\text{C}$ | 1.743 $^{\circ}\text{C}$ |                                                |
|               | 1820 $^{\circ}\text{C}$  | 2.202 $^{\circ}\text{C}$ | 1.842 $^{\circ}\text{C}$ |                                                |
| 1000 S/s      | 250 $^{\circ}\text{C}$   | 5.489 $^{\circ}\text{C}$ | 3.956 $^{\circ}\text{C}$ | 0.14                                           |
|               | 700 $^{\circ}\text{C}$   | 2.283 $^{\circ}\text{C}$ | 1.743 $^{\circ}\text{C}$ |                                                |
|               | 1820 $^{\circ}\text{C}$  | 2.202 $^{\circ}\text{C}$ | 1.842 $^{\circ}\text{C}$ |                                                |
| 500 S/s       | 250 $^{\circ}\text{C}$   | 4.387 $^{\circ}\text{C}$ | 2.885 $^{\circ}\text{C}$ | 0.14                                           |
|               | 700 $^{\circ}\text{C}$   | 1.879 $^{\circ}\text{C}$ | 1.340 $^{\circ}\text{C}$ |                                                |
|               | 1820 $^{\circ}\text{C}$  | 1.962 $^{\circ}\text{C}$ | 1.601 $^{\circ}\text{C}$ |                                                |
| 100 S/s       | 250 $^{\circ}\text{C}$   | 4.387 $^{\circ}\text{C}$ | 2.885 $^{\circ}\text{C}$ | 0.14                                           |
|               | 700 $^{\circ}\text{C}$   | 1.879 $^{\circ}\text{C}$ | 1.340 $^{\circ}\text{C}$ |                                                |
|               | 1820 $^{\circ}\text{C}$  | 1.962 $^{\circ}\text{C}$ | 1.601 $^{\circ}\text{C}$ |                                                |
| 60 S/s        | 250 $^{\circ}\text{C}$   | 4.387 $^{\circ}\text{C}$ | 2.885 $^{\circ}\text{C}$ | 0.14                                           |
|               | 700 $^{\circ}\text{C}$   | 1.879 $^{\circ}\text{C}$ | 1.340 $^{\circ}\text{C}$ |                                                |
|               | 1820 $^{\circ}\text{C}$  | 1.962 $^{\circ}\text{C}$ | 1.601 $^{\circ}\text{C}$ |                                                |
| 50 S/s        | 250 $^{\circ}\text{C}$   | 4.387 $^{\circ}\text{C}$ | 2.885 $^{\circ}\text{C}$ | 0.14                                           |
|               | 700 $^{\circ}\text{C}$   | 1.879 $^{\circ}\text{C}$ | 1.340 $^{\circ}\text{C}$ |                                                |
|               | 1820 $^{\circ}\text{C}$  | 1.962 $^{\circ}\text{C}$ | 1.601 $^{\circ}\text{C}$ |                                                |
| 25 S/s        | 250 $^{\circ}\text{C}$   | 4.387 $^{\circ}\text{C}$ | 2.885 $^{\circ}\text{C}$ | 0.14                                           |
|               | 700 $^{\circ}\text{C}$   | 1.879 $^{\circ}\text{C}$ | 1.340 $^{\circ}\text{C}$ |                                                |
|               | 1820 $^{\circ}\text{C}$  | 1.962 $^{\circ}\text{C}$ | 1.601 $^{\circ}\text{C}$ |                                                |
| 10 S/s        | 250 $^{\circ}\text{C}$   | 4.387 $^{\circ}\text{C}$ | 2.885 $^{\circ}\text{C}$ | 0.14                                           |
|               | 700 $^{\circ}\text{C}$   | 1.879 $^{\circ}\text{C}$ | 1.340 $^{\circ}\text{C}$ |                                                |
|               | 1820 $^{\circ}\text{C}$  | 1.962 $^{\circ}\text{C}$ | 1.601 $^{\circ}\text{C}$ |                                                |
| 5 S/s         | 250 $^{\circ}\text{C}$   | 4.387 $^{\circ}\text{C}$ | 2.885 $^{\circ}\text{C}$ | 0.14                                           |
|               | 700 $^{\circ}\text{C}$   | 1.879 $^{\circ}\text{C}$ | 1.340 $^{\circ}\text{C}$ |                                                |
|               | 1820 $^{\circ}\text{C}$  | 1.962 $^{\circ}\text{C}$ | 1.601 $^{\circ}\text{C}$ |                                                |
| 2.5 S/s       | 250 $^{\circ}\text{C}$   | 4.387 $^{\circ}\text{C}$ | 2.885 $^{\circ}\text{C}$ | 0.14                                           |
|               | 700 $^{\circ}\text{C}$   | 1.879 $^{\circ}\text{C}$ | 1.340 $^{\circ}\text{C}$ |                                                |
|               | 1820 $^{\circ}\text{C}$  | 1.962 $^{\circ}\text{C}$ | 1.601 $^{\circ}\text{C}$ |                                                |

To achieve the thermocouple accuracies listed above, the USB-2416-4AO should be warmed up for 45 minutes after the initial power on. The accuracies listed above are only guaranteed if the USB-2416-4AO is housed in its plastic enclosure.

Table 10. E type thermocouple accuracy specifications, including CJC measurement error.  
All specifications are ( $\pm$ ).

| A/D data rate | Sensor temperature range | Accuracy error maximum   | Accuracy error typical   | Tempco ( $^{\circ}\text{C}/^{\circ}\text{C}$ ) |
|---------------|--------------------------|--------------------------|--------------------------|------------------------------------------------|
| 3750 S/s      | -200 $^{\circ}\text{C}$  | 2.413 $^{\circ}\text{C}$ | 1.352 $^{\circ}\text{C}$ | 0.017                                          |
|               | 0 $^{\circ}\text{C}$     | 1.069 $^{\circ}\text{C}$ | 0.551 $^{\circ}\text{C}$ |                                                |
|               | 1000 $^{\circ}\text{C}$  | 1.575 $^{\circ}\text{C}$ | 1.211 $^{\circ}\text{C}$ |                                                |
| 2000 S/s      | -200 $^{\circ}\text{C}$  | 2.413 $^{\circ}\text{C}$ | 1.352 $^{\circ}\text{C}$ | 0.017                                          |
|               | 0 $^{\circ}\text{C}$     | 1.069 $^{\circ}\text{C}$ | 0.551 $^{\circ}\text{C}$ |                                                |
|               | 1000 $^{\circ}\text{C}$  | 1.575 $^{\circ}\text{C}$ | 1.211 $^{\circ}\text{C}$ |                                                |
| 1000 S/s      | -200 $^{\circ}\text{C}$  | 2.413 $^{\circ}\text{C}$ | 1.352 $^{\circ}\text{C}$ | 0.017                                          |
|               | 0 $^{\circ}\text{C}$     | 1.069 $^{\circ}\text{C}$ | 0.551 $^{\circ}\text{C}$ |                                                |
|               | 1000 $^{\circ}\text{C}$  | 1.575 $^{\circ}\text{C}$ | 1.211 $^{\circ}\text{C}$ |                                                |
| 500 S/s       | -200 $^{\circ}\text{C}$  | 2.306 $^{\circ}\text{C}$ | 1.244 $^{\circ}\text{C}$ | 0.017                                          |
|               | 0 $^{\circ}\text{C}$     | 1.017 $^{\circ}\text{C}$ | 0.499 $^{\circ}\text{C}$ |                                                |
|               | 1000 $^{\circ}\text{C}$  | 1.539 $^{\circ}\text{C}$ | 1.175 $^{\circ}\text{C}$ |                                                |
| 100 S/s       | -200 $^{\circ}\text{C}$  | 2.306 $^{\circ}\text{C}$ | 1.244 $^{\circ}\text{C}$ | 0.017                                          |
|               | 0 $^{\circ}\text{C}$     | 1.017 $^{\circ}\text{C}$ | 0.499 $^{\circ}\text{C}$ |                                                |
|               | 1000 $^{\circ}\text{C}$  | 1.539 $^{\circ}\text{C}$ | 1.175 $^{\circ}\text{C}$ |                                                |
| 60 S/s        | -200 $^{\circ}\text{C}$  | 2.306 $^{\circ}\text{C}$ | 1.244 $^{\circ}\text{C}$ | 0.017                                          |
|               | 0 $^{\circ}\text{C}$     | 1.017 $^{\circ}\text{C}$ | 0.499 $^{\circ}\text{C}$ |                                                |
|               | 1000 $^{\circ}\text{C}$  | 1.539 $^{\circ}\text{C}$ | 1.175 $^{\circ}\text{C}$ |                                                |
| 50 S/s        | -200 $^{\circ}\text{C}$  | 2.306 $^{\circ}\text{C}$ | 1.244 $^{\circ}\text{C}$ | 0.017                                          |
|               | 0 $^{\circ}\text{C}$     | 1.017 $^{\circ}\text{C}$ | 0.499 $^{\circ}\text{C}$ |                                                |
|               | 1000 $^{\circ}\text{C}$  | 1.539 $^{\circ}\text{C}$ | 1.175 $^{\circ}\text{C}$ |                                                |
| 25 S/s        | -200 $^{\circ}\text{C}$  | 2.306 $^{\circ}\text{C}$ | 1.244 $^{\circ}\text{C}$ | 0.017                                          |
|               | 0 $^{\circ}\text{C}$     | 1.017 $^{\circ}\text{C}$ | 0.499 $^{\circ}\text{C}$ |                                                |
|               | 1000 $^{\circ}\text{C}$  | 1.539 $^{\circ}\text{C}$ | 1.175 $^{\circ}\text{C}$ |                                                |
| 10 S/s        | -200 $^{\circ}\text{C}$  | 2.306 $^{\circ}\text{C}$ | 1.244 $^{\circ}\text{C}$ | 0.017                                          |
|               | 0 $^{\circ}\text{C}$     | 1.017 $^{\circ}\text{C}$ | 0.499 $^{\circ}\text{C}$ |                                                |
|               | 1000 $^{\circ}\text{C}$  | 1.539 $^{\circ}\text{C}$ | 1.175 $^{\circ}\text{C}$ |                                                |
| 5 S/s         | -200 $^{\circ}\text{C}$  | 2.306 $^{\circ}\text{C}$ | 1.244 $^{\circ}\text{C}$ | 0.017                                          |
|               | 0 $^{\circ}\text{C}$     | 1.017 $^{\circ}\text{C}$ | 0.499 $^{\circ}\text{C}$ |                                                |
|               | 1000 $^{\circ}\text{C}$  | 1.539 $^{\circ}\text{C}$ | 1.175 $^{\circ}\text{C}$ |                                                |
| 2.5 S/s       | -200 $^{\circ}\text{C}$  | 2.306 $^{\circ}\text{C}$ | 1.244 $^{\circ}\text{C}$ | 0.017                                          |
|               | 0 $^{\circ}\text{C}$     | 1.017 $^{\circ}\text{C}$ | 0.499 $^{\circ}\text{C}$ |                                                |
|               | 1000 $^{\circ}\text{C}$  | 1.539 $^{\circ}\text{C}$ | 1.175 $^{\circ}\text{C}$ |                                                |

To achieve the thermocouple accuracies listed above, the USB-2416-4AO should be warmed up for 45 minutes after the initial power on. The accuracies listed above are only guaranteed if the USB-2416-4AO is housed in its plastic enclosure.

Table 11. T type thermocouple accuracy specifications, including CJC measurement error.  
All specifications are ( $\pm$ ).

| A/D data rate | Sensor temperature range | Accuracy error maximum   | Accuracy error typical   | Tempco ( $^{\circ}\text{C}/^{\circ}\text{C}$ ) |
|---------------|--------------------------|--------------------------|--------------------------|------------------------------------------------|
| 3750 S/s      | -200 $^{\circ}\text{C}$  | 2.821 $^{\circ}\text{C}$ | 1.676 $^{\circ}\text{C}$ | 0.027                                          |
|               | 0 $^{\circ}\text{C}$     | 1.050 $^{\circ}\text{C}$ | 0.558 $^{\circ}\text{C}$ |                                                |
|               | 400 $^{\circ}\text{C}$   | 0.957 $^{\circ}\text{C}$ | 0.595 $^{\circ}\text{C}$ |                                                |
| 2000 S/s      | -200 $^{\circ}\text{C}$  | 2.821 $^{\circ}\text{C}$ | 1.676 $^{\circ}\text{C}$ | 0.027                                          |
|               | 0 $^{\circ}\text{C}$     | 1.050 $^{\circ}\text{C}$ | 0.558 $^{\circ}\text{C}$ |                                                |
|               | 400 $^{\circ}\text{C}$   | 0.957 $^{\circ}\text{C}$ | 0.595 $^{\circ}\text{C}$ |                                                |
| 1000 S/s      | -200 $^{\circ}\text{C}$  | 2.821 $^{\circ}\text{C}$ | 1.676 $^{\circ}\text{C}$ | 0.027                                          |
|               | 0 $^{\circ}\text{C}$     | 1.050 $^{\circ}\text{C}$ | 0.558 $^{\circ}\text{C}$ |                                                |
|               | 400 $^{\circ}\text{C}$   | 0.957 $^{\circ}\text{C}$ | 0.595 $^{\circ}\text{C}$ |                                                |
| 500 S/s       | -200 $^{\circ}\text{C}$  | 2.644 $^{\circ}\text{C}$ | 1.505 $^{\circ}\text{C}$ | 0.027                                          |
|               | 0 $^{\circ}\text{C}$     | 0.979 $^{\circ}\text{C}$ | 0.487 $^{\circ}\text{C}$ |                                                |
|               | 400 $^{\circ}\text{C}$   | 0.912 $^{\circ}\text{C}$ | 0.551 $^{\circ}\text{C}$ |                                                |
| 100 S/s       | -200 $^{\circ}\text{C}$  | 2.644 $^{\circ}\text{C}$ | 1.505 $^{\circ}\text{C}$ | 0.027                                          |
|               | 0 $^{\circ}\text{C}$     | 0.979 $^{\circ}\text{C}$ | 0.487 $^{\circ}\text{C}$ |                                                |
|               | 400 $^{\circ}\text{C}$   | 0.912 $^{\circ}\text{C}$ | 0.551 $^{\circ}\text{C}$ |                                                |
| 60 S/s        | -200 $^{\circ}\text{C}$  | 2.644 $^{\circ}\text{C}$ | 1.505 $^{\circ}\text{C}$ | 0.027                                          |
|               | 0 $^{\circ}\text{C}$     | 0.979 $^{\circ}\text{C}$ | 0.487 $^{\circ}\text{C}$ |                                                |
|               | 400 $^{\circ}\text{C}$   | 0.912 $^{\circ}\text{C}$ | 0.551 $^{\circ}\text{C}$ |                                                |
| 50 S/s        | -200 $^{\circ}\text{C}$  | 2.644 $^{\circ}\text{C}$ | 1.505 $^{\circ}\text{C}$ | 0.027                                          |
|               | 0 $^{\circ}\text{C}$     | 0.979 $^{\circ}\text{C}$ | 0.487 $^{\circ}\text{C}$ |                                                |
|               | 400 $^{\circ}\text{C}$   | 0.912 $^{\circ}\text{C}$ | 0.551 $^{\circ}\text{C}$ |                                                |
| 25 S/s        | -200 $^{\circ}\text{C}$  | 2.644 $^{\circ}\text{C}$ | 1.505 $^{\circ}\text{C}$ | 0.027                                          |
|               | 0 $^{\circ}\text{C}$     | 0.979 $^{\circ}\text{C}$ | 0.487 $^{\circ}\text{C}$ |                                                |
|               | 400 $^{\circ}\text{C}$   | 0.912 $^{\circ}\text{C}$ | 0.551 $^{\circ}\text{C}$ |                                                |
| 10 S/s        | -200 $^{\circ}\text{C}$  | 2.644 $^{\circ}\text{C}$ | 1.505 $^{\circ}\text{C}$ | 0.027                                          |
|               | 0 $^{\circ}\text{C}$     | 0.979 $^{\circ}\text{C}$ | 0.487 $^{\circ}\text{C}$ |                                                |
|               | 400 $^{\circ}\text{C}$   | 0.912 $^{\circ}\text{C}$ | 0.551 $^{\circ}\text{C}$ |                                                |
| 5 S/s         | -200 $^{\circ}\text{C}$  | 2.644 $^{\circ}\text{C}$ | 1.505 $^{\circ}\text{C}$ | 0.027                                          |
|               | 0 $^{\circ}\text{C}$     | 0.979 $^{\circ}\text{C}$ | 0.487 $^{\circ}\text{C}$ |                                                |
|               | 400 $^{\circ}\text{C}$   | 0.912 $^{\circ}\text{C}$ | 0.551 $^{\circ}\text{C}$ |                                                |
| 2.5 S/s       | -200 $^{\circ}\text{C}$  | 2.644 $^{\circ}\text{C}$ | 1.505 $^{\circ}\text{C}$ | 0.027                                          |
|               | 0 $^{\circ}\text{C}$     | 0.979 $^{\circ}\text{C}$ | 0.487 $^{\circ}\text{C}$ |                                                |
|               | 400 $^{\circ}\text{C}$   | 0.912 $^{\circ}\text{C}$ | 0.551 $^{\circ}\text{C}$ |                                                |

To achieve the thermocouple accuracies listed above, the USB-2416-4AO should be warmed up for 45 minutes after the initial power on. The accuracies listed above are only guaranteed if the USB-2416-4AO is housed in its plastic enclosure.

## Analog input DC voltage measurement accuracy

Table 12. DC Accuracy components and specifications. All values are ( $\pm$ )

| Range               | A/D data rate | Gain error (% of reading) | Offset error     | INL error (% of range) | Absolute accuracy     | Gain temperature coefficient (% reading/ $^{\circ}\text{C}$ ) | Offset temperature coefficient ( $\mu\text{V}/^{\circ}\text{C}$ ) |
|---------------------|---------------|---------------------------|------------------|------------------------|-----------------------|---------------------------------------------------------------|-------------------------------------------------------------------|
| $\pm 20\text{ V}$   | 3750 S/s      | 0.003                     | 98 $\mu\text{V}$ | 0.0008                 | 857.600 $\mu\text{V}$ | 0.0006                                                        | 3                                                                 |
|                     | 2000 S/s      | 0.003                     | 61 $\mu\text{V}$ | 0.0008                 | 821.185 $\mu\text{V}$ | 0.0006                                                        | 3                                                                 |
|                     | 1000 S/s      | 0.003                     | 27 $\mu\text{V}$ | 0.0008                 | 787.226 $\mu\text{V}$ | 0.0006                                                        | 3                                                                 |
|                     | 500 S/s       | 0.003                     | 12 $\mu\text{V}$ | 0.0008                 | 772.193 $\mu\text{V}$ | 0.0006                                                        | 3                                                                 |
|                     | 100 S/s       | 0.003                     | 11 $\mu\text{V}$ | 0.0008                 | 771.014 $\mu\text{V}$ | 0.0006                                                        | 3                                                                 |
|                     | 60 S/s        | 0.003                     | 15 $\mu\text{V}$ | 0.0008                 | 774.689 $\mu\text{V}$ | 0.0006                                                        | 3                                                                 |
|                     | 50 S/s        | 0.003                     | 12 $\mu\text{V}$ | 0.0008                 | 771.603 $\mu\text{V}$ | 0.0006                                                        | 3                                                                 |
|                     | 25 S/s        | 0.003                     | 12 $\mu\text{V}$ | 0.0008                 | 772.070 $\mu\text{V}$ | 0.0006                                                        | 3                                                                 |
|                     | 10 S/s        | 0.003                     | 13 $\mu\text{V}$ | 0.0008                 | 773.400 $\mu\text{V}$ | 0.0006                                                        | 3                                                                 |
|                     | 5 S/s         | 0.003                     | 14 $\mu\text{V}$ | 0.0008                 | 773.579 $\mu\text{V}$ | 0.0006                                                        | 3                                                                 |
|                     | 2.5 S/s       | 0.003                     | 14 $\mu\text{V}$ | 0.0008                 | 773.537 $\mu\text{V}$ | 0.0006                                                        | 3                                                                 |
| $\pm 10\text{ V}$   | 3750 S/s      | 0.003                     | 42 $\mu\text{V}$ | 0.0008                 | 421.600 $\mu\text{V}$ | 0.0006                                                        | 3                                                                 |
|                     | 2000 S/s      | 0.003                     | 36 $\mu\text{V}$ | 0.0008                 | 416.004 $\mu\text{V}$ | 0.0006                                                        | 3                                                                 |
|                     | 1000 S/s      | 0.003                     | 15 $\mu\text{V}$ | 0.0008                 | 395.252 $\mu\text{V}$ | 0.0006                                                        | 3                                                                 |
|                     | 500 S/s       | 0.003                     | 7 $\mu\text{V}$  | 0.0008                 | 387.216 $\mu\text{V}$ | 0.0006                                                        | 3                                                                 |
|                     | 100 S/s       | 0.002                     | 8 $\mu\text{V}$  | 0.0008                 | 288.470 $\mu\text{V}$ | 0.0006                                                        | 3                                                                 |
|                     | 60 S/s        | 0.002                     | 10 $\mu\text{V}$ | 0.0008                 | 290.090 $\mu\text{V}$ | 0.0006                                                        | 3                                                                 |
|                     | 50 S/s        | 0.002                     | 8 $\mu\text{V}$  | 0.0008                 | 287.719 $\mu\text{V}$ | 0.0006                                                        | 3                                                                 |
|                     | 25 S/s        | 0.002                     | 6 $\mu\text{V}$  | 0.0008                 | 285.672 $\mu\text{V}$ | 0.0006                                                        | 3                                                                 |
|                     | 10 S/s        | 0.002                     | 6 $\mu\text{V}$  | 0.0008                 | 285.982 $\mu\text{V}$ | 0.0006                                                        | 3                                                                 |
|                     | 5 S/s         | 0.002                     | 6 $\mu\text{V}$  | 0.0008                 | 286.003 $\mu\text{V}$ | 0.0006                                                        | 3                                                                 |
|                     | 2.5 S/s       | 0.002                     | 6 $\mu\text{V}$  | 0.0008                 | 286.086 $\mu\text{V}$ | 0.0006                                                        | 3                                                                 |
| $\pm 5\text{ V}$    | 3750 S/s      | 0.003                     | 21 $\mu\text{V}$ | 0.0008                 | 210.800 $\mu\text{V}$ | 0.0006                                                        | 2                                                                 |
|                     | 2000 S/s      | 0.003                     | 21 $\mu\text{V}$ | 0.0008                 | 210.712 $\mu\text{V}$ | 0.0006                                                        | 2                                                                 |
|                     | 1000 S/s      | 0.003                     | 8 $\mu\text{V}$  | 0.0008                 | 198.254 $\mu\text{V}$ | 0.0006                                                        | 2                                                                 |
|                     | 500 S/s       | 0.002                     | 6 $\mu\text{V}$  | 0.0008                 | 146.499 $\mu\text{V}$ | 0.0006                                                        | 2                                                                 |
|                     | 100 S/s       | 0.002                     | 7 $\mu\text{V}$  | 0.0008                 | 147.285 $\mu\text{V}$ | 0.0006                                                        | 2                                                                 |
|                     | 60 S/s        | 0.002                     | 8 $\mu\text{V}$  | 0.0008                 | 148.216 $\mu\text{V}$ | 0.0006                                                        | 2                                                                 |
|                     | 50 S/s        | 0.002                     | 6 $\mu\text{V}$  | 0.0008                 | 146.196 $\mu\text{V}$ | 0.0006                                                        | 2                                                                 |
|                     | 25 S/s        | 0.002                     | 6 $\mu\text{V}$  | 0.0008                 | 145.996 $\mu\text{V}$ | 0.0006                                                        | 2                                                                 |
|                     | 10 S/s        | 0.002                     | 6 $\mu\text{V}$  | 0.0008                 | 145.820 $\mu\text{V}$ | 0.0006                                                        | 2                                                                 |
|                     | 5 S/s         | 0.002                     | 6 $\mu\text{V}$  | 0.0008                 | 145.817 $\mu\text{V}$ | 0.0006                                                        | 2                                                                 |
|                     | 2.5 S/s       | 0.002                     | 6 $\mu\text{V}$  | 0.0008                 | 145.810 $\mu\text{V}$ | 0.0006                                                        | 2                                                                 |
| $\pm 2.5\text{ V}$  | 3750 S/s      | 0.002                     | 13 $\mu\text{V}$ | 0.0008                 | 83.000 $\mu\text{V}$  | 0.0006                                                        | 1                                                                 |
|                     | 2000 S/s      | 0.002                     | 13 $\mu\text{V}$ | 0.0008                 | 83.062 $\mu\text{V}$  | 0.0006                                                        | 1                                                                 |
|                     | 1000 S/s      | 0.002                     | 9 $\mu\text{V}$  | 0.0008                 | 79.487 $\mu\text{V}$  | 0.0006                                                        | 1                                                                 |
|                     | 500 S/s       | 0.0015                    | 9 $\mu\text{V}$  | 0.0008                 | 66.232 $\mu\text{V}$  | 0.0006                                                        | 1                                                                 |
|                     | 100 S/s       | 0.0015                    | 9 $\mu\text{V}$  | 0.0008                 | 66.685 $\mu\text{V}$  | 0.0006                                                        | 1                                                                 |
|                     | 60 S/s        | 0.0015                    | 10 $\mu\text{V}$ | 0.0008                 | 67.014 $\mu\text{V}$  | 0.0006                                                        | 1                                                                 |
|                     | 50 S/s        | 0.0015                    | 8 $\mu\text{V}$  | 0.0008                 | 65.314 $\mu\text{V}$  | 0.0006                                                        | 1                                                                 |
|                     | 25 S/s        | 0.0015                    | 8 $\mu\text{V}$  | 0.0008                 | 65.901 $\mu\text{V}$  | 0.0006                                                        | 1                                                                 |
|                     | 10 S/s        | 0.0015                    | 8 $\mu\text{V}$  | 0.0008                 | 65.759 $\mu\text{V}$  | 0.0006                                                        | 1                                                                 |
|                     | 5 S/s         | 0.0015                    | 8 $\mu\text{V}$  | 0.0008                 | 65.800 $\mu\text{V}$  | 0.0006                                                        | 1                                                                 |
|                     | 2.5 S/s       | 0.0015                    | 8 $\mu\text{V}$  | 0.0008                 | 65.769 $\mu\text{V}$  | 0.0006                                                        | 1                                                                 |
| $\pm 1.25\text{ V}$ | 3750 S/s      | 0.0025                    | 7 $\mu\text{V}$  | 0.0008                 | 48.050 $\mu\text{V}$  | 0.0006                                                        | 1                                                                 |

| Range       | A/D data rate | Gain error (% of reading) | Offset error | INL error (% of range) | Absolute accuracy | Gain temperature coefficient (% reading/°C) | Offset temperature coefficient (μV/°C) |
|-------------|---------------|---------------------------|--------------|------------------------|-------------------|---------------------------------------------|----------------------------------------|
|             | 2000 S/s      | 0.0025                    | 9 μV         | 0.0008                 | 50.632 μV         | 0.0006                                      | 1                                      |
|             | 1000 S/s      | 0.0025                    | 8 μV         | 0.0008                 | 49.359 μV         | 0.0006                                      | 1                                      |
|             | 500 S/s       | 0.0025                    | 8 μV         | 0.0008                 | 49.709 μV         | 0.0006                                      | 1                                      |
|             | 100 S/s       | 0.0025                    | 8 μV         | 0.0008                 | 49.604 μV         | 0.0006                                      | 1                                      |
|             | 60 S/s        | 0.0025                    | 8 μV         | 0.0008                 | 49.417 μV         | 0.0006                                      | 1                                      |
|             | 50 S/s        | 0.0025                    | 8 μV         | 0.0008                 | 49.610 μV         | 0.0006                                      | 1                                      |
|             | 25 S/s        | 0.0025                    | 8 μV         | 0.0008                 | 49.584 μV         | 0.0006                                      | 1                                      |
|             | 10 S/s        | 0.0025                    | 8 μV         | 0.0008                 | 49.482 μV         | 0.0006                                      | 1                                      |
|             | 5 S/s         | 0.0025                    | 8 μV         | 0.0008                 | 49.489 μV         | 0.0006                                      | 1                                      |
|             | 2.5 S/s       | 0.0025                    | 8 μV         | 0.0008                 | 49.489 μV         | 0.0006                                      | 1                                      |
| ±0.625 V    | 3750 S/s      | 0.003                     | 7 μV         | 0.0005                 | 28.775 μV         | 0.0006                                      | 1                                      |
|             | 2000 S/s      | 0.003                     | 7 μV         | 0.0005                 | 28.679 μV         | 0.0006                                      | 1                                      |
|             | 1000 S/s      | 0.003                     | 6 μV         | 0.0005                 | 27.762 μV         | 0.0006                                      | 1                                      |
|             | 500 S/s       | 0.003                     | 6 μV         | 0.0005                 | 28.167 μV         | 0.0006                                      | 1                                      |
|             | 100 S/s       | 0.003                     | 6 μV         | 0.0005                 | 28.088 μV         | 0.0006                                      | 1                                      |
|             | 60 S/s        | 0.002                     | 6 μV         | 0.0005                 | 21.709 μV         | 0.0006                                      | 1                                      |
|             | 50 S/s        | 0.002                     | 6 μV         | 0.0005                 | 21.773 μV         | 0.0006                                      | 1                                      |
|             | 25 S/s        | 0.002                     | 6 μV         | 0.0005                 | 21.746 μV         | 0.0006                                      | 1                                      |
|             | 10 S/s        | 0.002                     | 6 μV         | 0.0005                 | 21.927 μV         | 0.0006                                      | 1                                      |
|             | 5 S/s         | 0.002                     | 6 μV         | 0.0005                 | 21.803 μV         | 0.0006                                      | 1                                      |
|             | 2.5 S/s       | 0.002                     | 6 μV         | 0.0005                 | 21.784 μV         | 0.0006                                      | 1                                      |
| ±0.3125 V   | 3750 S/s      | 0.005                     | 7 μV         | 0.0006                 | 24.500 μV         | 0.0006                                      | 1                                      |
|             | 2000 S/s      | 0.005                     | 6 μV         | 0.0006                 | 23.443 μV         | 0.0006                                      | 1                                      |
|             | 1000 S/s      | 0.005                     | 6 μV         | 0.0006                 | 23.086 μV         | 0.0006                                      | 1                                      |
|             | 500 S/s       | 0.005                     | 6 μV         | 0.0006                 | 23.094 μV         | 0.0006                                      | 1                                      |
|             | 100 S/s       | 0.005                     | 6 μV         | 0.0006                 | 23.084 μV         | 0.0006                                      | 1                                      |
|             | 60 S/s        | 0.005                     | 6 μV         | 0.0006                 | 23.288 μV         | 0.0006                                      | 1                                      |
|             | 50 S/s        | 0.005                     | 6 μV         | 0.0006                 | 23.232 μV         | 0.0006                                      | 1                                      |
|             | 25 S/s        | 0.005                     | 6 μV         | 0.0006                 | 23.191 μV         | 0.0006                                      | 1                                      |
|             | 10 S/s        | 0.005                     | 6 μV         | 0.0006                 | 23.125 μV         | 0.0006                                      | 1                                      |
|             | 5 S/s         | 0.005                     | 6 μV         | 0.0006                 | 23.182 μV         | 0.0006                                      | 1                                      |
|             | 2.5 S/s       | 0.005                     | 6 μV         | 0.0006                 | 23.127 μV         | 0.0006                                      | 1                                      |
| ±0.15625 V  | 3750 S/s      | 0.006                     | 6 μV         | 0.0005                 | 15.856 μV         | 0.0006                                      | 1                                      |
|             | 2000 S/s      | 0.006                     | 6 μV         | 0.0005                 | 15.793 μV         | 0.0006                                      | 1                                      |
|             | 1000 S/s      | 0.006                     | 6 μV         | 0.0005                 | 15.902 μV         | 0.0006                                      | 1                                      |
|             | 500 S/s       | 0.006                     | 6 μV         | 0.0005                 | 16.118 μV         | 0.0006                                      | 1                                      |
|             | 100 S/s       | 0.006                     | 6 μV         | 0.0005                 | 15.877 μV         | 0.0006                                      | 1                                      |
|             | 60 S/s        | 0.006                     | 6 μV         | 0.0005                 | 16.014 μV         | 0.0006                                      | 1                                      |
|             | 50 S/s        | 0.006                     | 6 μV         | 0.0005                 | 16.122 μV         | 0.0006                                      | 1                                      |
|             | 25 S/s        | 0.006                     | 6 μV         | 0.0005                 | 15.903 μV         | 0.0006                                      | 1                                      |
|             | 10 S/s        | 0.006                     | 6 μV         | 0.0005                 | 15.927 μV         | 0.0006                                      | 1                                      |
|             | 5 S/s         | 0.006                     | 6 μV         | 0.0005                 | 15.981 μV         | 0.0006                                      | 1                                      |
|             | 2.5 S/s       | 0.006                     | 6 μV         | 0.0005                 | 15.979 μV         | 0.0006                                      | 1                                      |
| ±0.078125 V | 3750 S/s      | 0.035                     | 6 μV         | 0.0009                 | 33.547 μV         | 0.0006                                      | 1                                      |
|             | 2000 S/s      | 0.035                     | 6 μV         | 0.0009                 | 34.252 μV         | 0.0006                                      | 1                                      |
|             | 1000 S/s      | 0.035                     | 6 μV         | 0.0009                 | 33.696 μV         | 0.0006                                      | 1                                      |
|             | 500 S/s       | 0.035                     | 6 μV         | 0.0009                 | 34.002 μV         | 0.0006                                      | 1                                      |
|             | 100 S/s       | 0.035                     | 6 μV         | 0.0009                 | 34.005 μV         | 0.0006                                      | 1                                      |

| Range | A/D data rate | Gain error (% of reading) | Offset error | INL error (% of range) | Absolute accuracy | Gain temperature coefficient (% reading/°C) | Offset temperature coefficient (μV/°C) |
|-------|---------------|---------------------------|--------------|------------------------|-------------------|---------------------------------------------|----------------------------------------|
|       | 60 S/s        | 0.035                     | 6 μV         | 0.0009                 | 33.866 μV         | 0.0006                                      | 1                                      |
|       | 50 S/s        | 0.035                     | 6 μV         | 0.0009                 | 34.026 μV         | 0.0006                                      | 1                                      |
|       | 25 S/s        | 0.035                     | 6 μV         | 0.0009                 | 33.933 μV         | 0.0006                                      | 1                                      |
|       | 10 S/s        | 0.035                     | 6 μV         | 0.0009                 | 33.937 μV         | 0.0006                                      | 1                                      |
|       | 5 S/s         | 0.035                     | 6 μV         | 0.0009                 | 33.969 μV         | 0.0006                                      | 1                                      |
|       | 2.5 S/s       | 0.035                     | 6 μV         | 0.0009                 | 33.934 μV         | 0.0006                                      | 1                                      |

## Input bandwidth

Table 13. input bandwidth

| A/D data rate | -3 db Bandwidth (Hz) |
|---------------|----------------------|
| 3750 S/s      | 1615                 |
| 2000 S/s      | 878                  |
| 1000 S/s      | 441                  |
| 500 S/s       | 221                  |
| 100 S/s       | 44.2                 |
| 60 S/s        | 26.5                 |
| 50 S/s        | 22.1                 |
| 25 S/s        | 11.1                 |
| 10 S/s        | 4.42                 |
| 5 S/s         | 2.21                 |
| 2.5 S/s       | 1.1                  |

## Noise performance

For the peak-to-peak noise distribution test, a differential input channel is connected to GND at the input terminal block, and 50,000 samples are acquired at the maximum rate available at each setting.

Table 14. Peak-to-peak noise performance specifications (μV)

|             | A/D data rate |          |          |         |         |        |        |        |        |       |         |
|-------------|---------------|----------|----------|---------|---------|--------|--------|--------|--------|-------|---------|
| Range       | 3750 S/s      | 2000 S/s | 1000 S/s | 500 S/s | 100 S/s | 60 S/s | 50 S/s | 25 S/s | 10 S/s | 5 S/s | 2.5 S/s |
| ±20 V       | 230.31        | 186.92   | 126.84   | 100.14  | 57.22   | 57.22  | 49.59  | 47.58  | 23.84  | 23.84 | 14.31   |
| ±10 V       | 126.84        | 100.14   | 71.76    | 45.06   | 30.52   | 30.52  | 26.70  | 19.07  | 11.92  | 9.54  | 9.54    |
| ±5 V        | 56.74         | 47.56    | 34.21    | 25.87   | 16.21   | 14.31  | 14.31  | 14.30  | 5.96   | 4.77  | 4.77    |
| ±2.5 V      | 32.96         | 28.79    | 17.94    | 14.19   | 7.51    | 7.09   | 7.09   | 5.72   | 3.81   | 2.86  | 2.38    |
| ±1.25 V     | 18.57         | 17.52    | 13.83    | 9.30    | 5.48    | 5.48   | 5.01   | 3.81   | 3.34   | 3.34  | 2.86    |
| ±0.625 V    | 18.88         | 16.58    | 8.45     | 7.41    | 5.32    | 4.80   | 4.38   | 3.86   | 2.50   | 2.61  | 1.98    |
| ±0.3125 V   | 15.33         | 14.76    | 8.19     | 6.94    | 4.75    | 4.69   | 4.49   | 3.70   | 3.34   | 2.56  | 2.45    |
| ±0.15625 V  | 13.28         | 16.84    | 7.47     | 6.61    | 5.70    | 4.48   | 4.48   | 4.24   | 2.66   | 3.07  | 2.29    |
| ±0.078125 V | 13.47         | 15.02    | 9.17     | 6.88    | 4.28    | 4.16   | 4.00   | 3.57   | 2.28   | 2.13  | 2.40    |

Table 15. RMS noise performance specifications ( $\mu\text{VRMS}$ )

|                          | A/D data rate |          |          |         |         |        |        |        |        |       |         |
|--------------------------|---------------|----------|----------|---------|---------|--------|--------|--------|--------|-------|---------|
| Range                    | 3750 S/s      | 2000 S/s | 1000 S/s | 500 S/s | 100 S/s | 60 S/s | 50 S/s | 25 S/s | 10 S/s | 5 S/s | 2.5 S/s |
| $\pm 20 \text{ V}$       | 34.90         | 28.32    | 19.22    | 15.17   | 8.67    | 8.67   | 7.51   | 7.22   | 3.61   | 3.61  | 2.17    |
| $\pm 10 \text{ V}$       | 19.22         | 15.17    | 10.87    | 6.83    | 4.62    | 4.62   | 4.05   | 2.89   | 1.81   | 1.44  | 1.44    |
| $\pm 5 \text{ V}$        | 8.60          | 7.21     | 5.18     | 3.92    | 2.46    | 2.17   | 2.17   | 2.16   | 0.90   | 0.72  | 0.72    |
| $\pm 2.5 \text{ V}$      | 4.99          | 4.36     | 2.72     | 2.15    | 1.14    | 1.07   | 1.07   | 0.87   | 0.58   | 0.43  | 0.36    |
| $\pm 1.25 \text{ V}$     | 2.81          | 2.66     | 2.10     | 1.41    | 0.83    | 0.83   | 0.76   | 0.58   | 0.51   | 0.51  | 0.43    |
| $\pm 0.625 \text{ V}$    | 2.86          | 2.51     | 1.28     | 1.12    | 0.81    | 0.73   | 0.66   | 0.58   | 0.38   | 0.40  | 0.30    |
| $\pm 0.3125 \text{ V}$   | 2.32          | 2.24     | 1.24     | 1.05    | 0.72    | 0.71   | 0.68   | 0.56   | 0.51   | 0.39  | 0.37    |
| $\pm 0.15625 \text{ V}$  | 2.01          | 2.55     | 1.13     | 1.00    | 0.86    | 0.68   | 0.68   | 0.64   | 0.40   | 0.47  | 0.35    |
| $\pm 0.078125 \text{ V}$ | 2.04          | 2.28     | 1.39     | 1.04    | 0.65    | 0.63   | 0.60   | 0.54   | 0.35   | 0.32  | 0.36    |

Table 16. Noise-free resolution specifications (bits)

|                          | A/D data rate |          |          |         |         |        |        |        |        |       |         |
|--------------------------|---------------|----------|----------|---------|---------|--------|--------|--------|--------|-------|---------|
| Range                    | 3750 S/s      | 2000 S/s | 1000 S/s | 500 S/s | 100 S/s | 60 S/s | 50 S/s | 25 S/s | 10 S/s | 5 S/s | 2.5 S/s |
| $\pm 20 \text{ V}$       | 17.4          | 17.7     | 18.2     | 18.6    | 19.4    | 19.4   | 19.6   | 19.6   | 20.6   | 20.6  | 21.4    |
| $\pm 10 \text{ V}$       | 17.2          | 17.6     | 18.1     | 18.7    | 19.3    | 19.3   | 19.5   | 20.0   | 20.6   | 21.0  | 21.0    |
| $\pm 5 \text{ V}$        | 17.4          | 17.6     | 18.1     | 18.5    | 19.2    | 19.4   | 19.4   | 19.4   | 20.6   | 21.0  | 21.0    |
| $\pm 2.5 \text{ V}$      | 17.2          | 17.4     | 18.1     | 18.4    | 19.3    | 19.4   | 19.4   | 19.7   | 20.3   | 20.7  | 21.0    |
| $\pm 1.25 \text{ V}$     | 17.0          | 17.1     | 17.4     | 18.0    | 18.8    | 18.8   | 18.9   | 19.3   | 19.5   | 19.5  | 19.7    |
| $\pm 0.625 \text{ V}$    | 16.0          | 16.2     | 17.1     | 17.3    | 17.8    | 18.0   | 18.1   | 18.3   | 18.9   | 18.8  | 19.2    |
| $\pm 0.3125 \text{ V}$   | 15.3          | 15.3     | 16.2     | 16.4    | 17.0    | 17.0   | 17.0   | 17.3   | 17.5   | 17.9  | 17.9    |
| $\pm 0.15625 \text{ V}$  | 14.5          | 14.1     | 15.3     | 15.5    | 15.7    | 16.1   | 16.1   | 16.1   | 16.8   | 16.9  | 17.1    |
| $\pm 0.078125 \text{ V}$ | 14.5          | 14.3     | 15.0     | 15.4    | 16.1    | 16.2   | 16.2   | 16.4   | 17.0   | 17.1  | 16.9    |

## Channel switching error

Table 17. Step response accuracy specifications

|                          | Accuracy |          |          |         |         |         |         |         |         |         |         |
|--------------------------|----------|----------|----------|---------|---------|---------|---------|---------|---------|---------|---------|
| Range                    | 3750 S/s | 2000 S/s | 1000 S/s | 500 S/s | 100 S/s | 60 S/s  | 50 S/s  | 25 S/s  | 10 S/s  | 5 S/s   | 2.5 S/s |
| $\pm 20 \text{ V}$       | 0.0011%  | 0.0006%  | 0.0004%  | 0.0003% | 0.0002% | 0.0002% | 0.0002% | 0.0002% | 0.0001% | 0.0001% | 0.0001% |
| $\pm 10 \text{ V}$       | 0.0010%  | 0.0008%  | 0.0005%  | 0.0004% | 0.0002% | 0.0002% | 0.0003% | 0.0002% | 0.0001% | 0.0001% | 0.0001% |
| $\pm 5 \text{ V}$        | 0.0009%  | 0.0008%  | 0.0004%  | 0.0004% | 0.0003% | 0.0002% | 0.0002% | 0.0002% | 0.0001% | 0.0001% | 0.0001% |
| $\pm 2.5 \text{ V}$      | 0.0010%  | 0.0007%  | 0.0008%  | 0.0004% | 0.0003% | 0.0002% | 0.0002% | 0.0002% | 0.0002% | 0.0001% | 0.0001% |
| $\pm 1.25 \text{ V}$     | 0.0013%  | 0.0009%  | 0.0008%  | 0.0007% | 0.0004% | 0.0004% | 0.0003% | 0.0003% | 0.0003% | 0.0003% | 0.0003% |
| $\pm 0.625 \text{ V}$    | 0.0022%  | 0.0016%  | 0.0011%  | 0.0011% | 0.0007% | 0.0007% | 0.0005% | 0.0005% | 0.0004% | 0.0005% | 0.0003% |
| $\pm 0.3125 \text{ V}$   | 0.0031%  | 0.0031%  | 0.0020%  | 0.0017% | 0.0015% | 0.0012% | 0.0010% | 0.0010% | 0.0012% | 0.0009% | 0.0009% |
| $\pm 0.15625 \text{ V}$  | 0.0056%  | 0.0062%  | 0.0048%  | 0.0037% | 0.0032% | 0.0025% | 0.0024% | 0.0021% | 0.0019% | 0.0022% | 0.0016% |
| $\pm 0.078125 \text{ V}$ | 0.0114%  | 0.0123%  | 0.0076%  | 0.0070% | 0.0041% | 0.0051% | 0.0046% | 0.0036% | 0.0032% | 0.0030% | 0.0034% |

Channel switching error is defined as the accuracy that can be expected after one conversion when switching from a channel with a DC input at one extreme of full scale to another channel with a DC input at the other extreme of full scale, expressed in terms of percentage of full scale value.

## Throughput rate

The single channel throughput rate is calculated using this formula:

$$\text{Maximum throughput} = \frac{1}{\frac{1}{\text{data rate}} + 640 \mu\text{s}}$$

Table 18. Single channel throughput rate specifications

| A/D data rate | Maximum throughput (Hz) |
|---------------|-------------------------|
| 3750 S/s      | 1102.94                 |
| 2000 S/s      | 877.19                  |
| 1000 S/s      | 609.76                  |
| 500 S/s       | 378.79                  |
| 100 S/s       | 93.98                   |
| 60 S/s        | 57.78                   |
| 50 S/s        | 48.45                   |
| 25 S/s        | 24.61                   |
| 10 S/s        | 9.94                    |
| 5 S/s         | 4.98                    |
| 2.5 S/s       | 2.50                    |

The multiple-channel throughput rate is calculated using this formula:

$$\text{Maximum throughput} = \frac{1}{\sum_n \left( \frac{1}{\text{data rate}} + 640 \mu\text{s} \right)}, \text{ where } n \text{ is the number of channels.}$$

Table 19. Multiple-channel throughput rate specifications (Hz)

|                          | 3750 S/s | 2000 S/s | 1000 S/s | 500 S/s | 100 S/s | 60 S/s | 50 S/s | 25 S/s | 10 S/s | 5 S/s | 2.5 S/s |
|--------------------------|----------|----------|----------|---------|---------|--------|--------|--------|--------|-------|---------|
| Number of input channels |          |          |          |         |         |        |        |        |        |       |         |
| 1                        | 1102.94  | 877.19   | 609.76   | 378.79  | 93.98   | 57.78  | 48.45  | 24.61  | 9.94   | 4.98  | 2.50    |
| 2                        | 551.47   | 438.60   | 304.88   | 189.39  | 46.99   | 28.89  | 24.22  | 12.30  | 4.97   | 2.49  | 1.25    |
| 3                        | 367.65   | 292.40   | 203.25   | 126.26  | 31.33   | 19.26  | 16.15  | 8.20   | 3.31   | 1.66  | 0.83    |
| 4                        | 275.74   | 219.30   | 152.44   | 94.70   | 23.50   | 14.45  | 12.11  | 6.15   | 2.48   | 1.25  | 0.62    |
| 5                        | 220.59   | 175.44   | 121.95   | 75.76   | 18.80   | 11.56  | 9.69   | 4.92   | 1.99   | 1.00  | 0.50    |
| 6                        | 183.82   | 146.20   | 101.63   | 63.13   | 15.66   | 9.63   | 8.07   | 4.10   | 1.66   | 0.83  | 0.42    |
| 7                        | 157.56   | 125.31   | 87.11    | 54.11   | 13.43   | 8.25   | 6.92   | 3.52   | 1.42   | 0.71  | 0.36    |
| 8                        | 137.87   | 109.65   | 76.22    | 47.35   | 11.75   | 7.22   | 6.06   | 3.08   | 1.24   | 0.62  | 0.31    |
| 9                        | 122.55   | 97.47    | 67.75    | 42.09   | 10.44   | 6.42   | 5.38   | 2.73   | 1.10   | 0.55  | 0.28    |
| 10                       | 110.29   | 87.72    | 60.98    | 37.88   | 9.40    | 5.78   | 4.84   | 2.46   | 0.99   | 0.50  | 0.25    |
| 11                       | 100.27   | 79.74    | 55.43    | 34.44   | 8.54    | 5.25   | 4.40   | 2.24   | 0.90   | 0.45  | 0.23    |
| 12                       | 91.91    | 73.10    | 50.81    | 31.57   | 7.83    | 4.82   | 4.04   | 2.05   | 0.83   | 0.42  | 0.21    |
| 13                       | 84.84    | 67.48    | 46.90    | 29.14   | 7.23    | 4.44   | 3.73   | 1.89   | 0.76   | 0.38  | 0.19    |
| 14                       | 78.78    | 62.66    | 43.55    | 27.06   | 6.71    | 4.13   | 3.46   | 1.76   | 0.71   | 0.36  | 0.18    |
| 15                       | 73.53    | 58.48    | 40.65    | 25.25   | 6.27    | 3.85   | 3.23   | 1.64   | 0.66   | 0.33  | 0.17    |
| 16                       | 68.93    | 54.82    | 38.11    | 23.67   | 5.87    | 3.61   | 3.03   | 1.54   | 0.62   | 0.31  | 0.16    |

## Analog voltage output

Unused VDACx output channels should be left disconnected.

The USB-2416-4AO output voltage level defaults to 0 V whenever the host PC is reset, shut down or suspended, or if a reset command is issued to the device.

The duration of the output transient depends highly on the enumeration process of the host PC. Typically, the output of the USB-2416-4AO is stable after two seconds.

Table 20. Analog voltage output specifications

| Parameter                       | Conditions                                                                                                                      | Specifications                                                                                       |
|---------------------------------|---------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|
| Digital-to-analog converter     |                                                                                                                                 | DAC8555                                                                                              |
| Number of channels              |                                                                                                                                 | 4                                                                                                    |
| Resolution                      |                                                                                                                                 | 16 bits                                                                                              |
| Output ranges                   | Calibrated                                                                                                                      | $\pm 10$ V                                                                                           |
|                                 | Uncalibrated                                                                                                                    | $\pm 10.05$ V, software configurable                                                                 |
| Output transient                | Host PC is reset, powered on, suspended or a reset command is issued to device (refer to the output transient discussion above) | Duration: 2 s<br>Amplitude: 2 V p-p                                                                  |
|                                 | Initial power on                                                                                                                | Duration: 50 ms<br>Amplitude: 5 V peak                                                               |
| Differential non-linearity      |                                                                                                                                 | $\pm 0.25$ LSB typical<br>$\pm 1$ LSB maximum                                                        |
| Output current                  | VDACx pins                                                                                                                      | $\pm 3.5$ mA maximum                                                                                 |
| Output short-circuit protection | VDACx connected to AGND                                                                                                         | Unlimited duration                                                                                   |
| Output coupling                 |                                                                                                                                 | DC                                                                                                   |
| VDACx readback                  |                                                                                                                                 | Each VDACx output can be independently measured by the onboard A/D converter.<br>Software selectable |
| Power on and reset state        |                                                                                                                                 | DACs cleared to zero-scale: 0 V, $\pm 50$ mV                                                         |
| Output noise                    |                                                                                                                                 | 30 $\mu$ Vrms                                                                                        |
| Settling time                   | To rated accuracy, 10 V step                                                                                                    | 45 $\mu$ s                                                                                           |
| Slew rate                       |                                                                                                                                 | 1.0 V/ $\mu$ s                                                                                       |
| Throughput                      | Single-channel                                                                                                                  | 1000 S/s maximum, system-dependent                                                                   |
|                                 | Multi-channel                                                                                                                   | 1000 S/s / #ch maximum, system-dependent                                                             |

Table 21. Calibrated absolute accuracy specifications

| Range      | Accuracy ( $\pm$ LSB) |
|------------|-----------------------|
| $\pm 10$ V | 16.0                  |

Table 22. Calibrated absolute accuracy components specifications

| Range      | % of reading | Offset ( $\pm$ mV) | Temp drift (%/ $^{\circ}$ C) | Absolute accuracy at FS ( $\pm$ mV) |
|------------|--------------|--------------------|------------------------------|-------------------------------------|
| $\pm 10$ V | $\pm 0.0183$ | 1.831              | 0.00055                      | 3.661                               |

Table 23. Relative accuracy specifications

| Range      | Relative accuracy ( $\pm$ LSB) |
|------------|--------------------------------|
| $\pm 10$ V | 4.0 typical                    |

## Analog input/output calibration

Table 24. Analog input/output calibration specifications

| Parameter                | Specifications                                                         |
|--------------------------|------------------------------------------------------------------------|
| Recommended warm-up time | 45 minutes minimum                                                     |
| Calibration              | Firmware calibration                                                   |
| Calibration interval     | 1 year                                                                 |
| Calibration reference    | +10.000 V, $\pm 5$ mV maximum. Actual measured values stored in EEPROM |
|                          | Tempco: 5 ppm/°C maximum                                               |
|                          | Long term stability: 30 ppm/1000 hours                                 |

## Digital input/output

Table 25. Digital input specifications

|                                 |                                                                                                                                                                                                                       |
|---------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Number of I/O                   | 8 channels                                                                                                                                                                                                            |
| Configuration                   | Each DIO bit can be independently read from (DIN) or written to (DOUT). The DIN bits can be read at any time whether the DOUT is active or tri-stated.                                                                |
| Input voltage range             | 0 to +15 V                                                                                                                                                                                                            |
| Input type                      | CMOS (Schmitt trigger)                                                                                                                                                                                                |
| Input characteristics           | 47 k $\Omega$ pull-up/pull-down resistor, 28 k $\Omega$ series resistor                                                                                                                                               |
| Maximum input voltage range     | 0 to +20 V maximum (power on/off, relative to DGND pins 93 and 94)                                                                                                                                                    |
| Pull-up/pull-down configuration | All pins pulled up to +5 V via individual 47 k $\Omega$ resistors (the JP1 shorting block default position is pins 1 and 2). Pull down capability is available by placing the JP1 shorting block across pins 2 and 3. |
| Transfer rate (software paced)  | 500 port reads or single bit reads per second typical.                                                                                                                                                                |
| Input high voltage              | 1.3 V minimum, 2.2 V maximum                                                                                                                                                                                          |
| Input low voltage               | 1.5 V maximum, 0.6 V minimum                                                                                                                                                                                          |
| Schmitt trigger hysteresis      | 0.4 V minimum, 1.2 V maximum                                                                                                                                                                                          |

**Note 2:** DGND pins (pins 93, 94) are recommended for use with digital input and digital output pins. The DGND and GND pins are common and are isolated from earth ground.

Table 26. Digital output specifications

|                                                 |                                                                                                                                                              |
|-------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Number of I/O                                   | 8 channels                                                                                                                                                   |
| Configuration                                   | Each DIO bit can be independently read from (DIN) or written to (DOUT). The DIN bits may be read at any time whether the DOUT is active or tri-stated        |
| Output characteristics                          | 47 k $\Omega$ pull-up, open drain (DMOS transistor)                                                                                                          |
| Pull-up configuration                           | All pins pulled up to +5 V via individual 47 k $\Omega$ resistors (the JP1 shorting block default position is pins 1 and 2).                                 |
| Transfer rate (software paced)                  | Digital output – 500 port writes or single-bit writes per second typical.                                                                                    |
| Output voltage range                            | 0 to +5 V (no external pull up resistor, internal 47 k $\Omega$ pull-up resistors connected to +5 V by default)<br>0 to +15 V maximum (Note 5)               |
| Drain to source breakdown voltage               | +50 V minimum                                                                                                                                                |
| Off state leakage current (Note 6)              | 0.1 $\mu$ A                                                                                                                                                  |
| Sink current capability                         | <ul style="list-style-type: none"> <li>■ 150 mA maximum (continuous) per output pin</li> <li>■ 150 mA maximum (continuous) for all eight channels</li> </ul> |
| DMOS transistor on-resistance (drain to source) | 4 $\Omega$                                                                                                                                                   |

**Note 3:** Each DMOS transistor's source pin is internally connected to GND.

**Note 4:** DGND pins (pins 93, 94) are recommended for use with digital input and digital output pins. The DGND and GND pins are common and are isolated from earth ground.

**Note 5:** The external pull-up is connected to the digital output bit through an external pull-up resistor. Adding an external pull-up resistor connects it in parallel with the internal 47 k $\Omega$  pull-up resistor of that particular digital input/output bit. Careful consideration should be made when considering the external pull-up resistor value and the resultant pull-up voltage produced at the load.

**Note 6:** Does not include the additional leakage current contribution that may occur when using an external pull-up resistor.

## Counter

Table 27. CTR specifications

| Parameter                                  | Conditions                                                                 | Specification                                                          |
|--------------------------------------------|----------------------------------------------------------------------------|------------------------------------------------------------------------|
| Pin name                                   |                                                                            | CTR0, CTR1                                                             |
| Number of channels                         |                                                                            | 2 channels                                                             |
| Resolution                                 |                                                                            | 32-bits                                                                |
| Counter type                               |                                                                            | Event counter                                                          |
| Input type                                 |                                                                            | Schmitt trigger, rising edge triggered                                 |
| Input source                               |                                                                            | CTR0 (pin 43)<br>CTR1 (pin 45)                                         |
| Counter read/writes rates (software paced) | Counter read                                                               | System dependent, 500 reads per second.                                |
|                                            | Counter write                                                              | System dependent, 500 writes per second.                               |
| Input characteristics                      | Each CTRx input pin                                                        | 562 K $\Omega$ pull-up resistor to +5 V, 10 k $\Omega$ series resistor |
| Input voltage range                        |                                                                            | $\pm 15$ V maximum                                                     |
| Maximum input voltage range                | CTR0,CTR1 relative to GND and DGND (pins 18,36,39,42,44,46,66,81,84,93,94) | $\pm 20$ V maximum (power on/off)                                      |
| Input high voltage                         |                                                                            | 1.3 V minimum, 2.2 V maximum                                           |
| Input low voltage                          |                                                                            | 1.5 V maximum, 0.6 V minimum                                           |
| Schmitt trigger hysteresis                 |                                                                            | 0.4 V minimum, 1.2 V maximum                                           |
| Input bandwidth ( $\sim 3$ dB)             |                                                                            | 1 MHz                                                                  |
| Input capacitance                          |                                                                            | 25 pF                                                                  |
| Input leakage current                      |                                                                            | $\pm 120$ nA                                                           |
| Input frequency                            |                                                                            | 1 MHz, maximum                                                         |
| High pulse width                           |                                                                            | 500 ns, minimum                                                        |
| Low pulse width                            |                                                                            | 500 ns, minimum                                                        |

**Note 7:** The DGND and GND pins (pins 18,36,39,42,44,46,66,81,84,93,94) are common and are isolated from earth ground.

## Memory

Table 28. Memory specifications

|        |                                                                                                                 |
|--------|-----------------------------------------------------------------------------------------------------------------|
| EEPROM | 4096 bytes isolated micro reserved for sensor configuration<br>256 bytes USB micro for external application use |
|--------|-----------------------------------------------------------------------------------------------------------------|

## Microcontroller

Table 29. Microcontroller specifications

|      |                                                                                                                                                                   |
|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Type | One high-performance 8-bit RISC microcontroller with USB interface (non-isolated)<br>One high-performance 16-bit RISC microcontroller for measurements (isolated) |
|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|

## Power

The USB-2416-4AO product includes an AC power adapter (MCC part number PS-5V2AEPS).

Table 30. Power specifications

| Parameter                      | Conditions                                                         | Specification                  |
|--------------------------------|--------------------------------------------------------------------|--------------------------------|
| Supply current (Note 8)        | Quiescent current                                                  | 340 mA                         |
| External power input (Note 9)  |                                                                    | +5 V, $\pm 5\%$                |
| External power supply          | MCC p/n PS-5V2AEPS (included)                                      | +5 VDC, 10 W, 5% regulation    |
| Voltage supervisor limits      | $4.5\text{ V} > V_{\text{ext}}$ or $V_{\text{ext}} > 5.5\text{ V}$ | PWR LED = Off; (power fault)   |
|                                | $4.5\text{ V} < V_{\text{ext}} < 5.5\text{ V}$                     | PWR LED = On                   |
| +5 V user output voltage range | Available at terminal block pin 35                                 | 4.9 V minimum to 5.1 V maximum |
| User +5V user output current   | Available at terminal block pin 35                                 | 10 mA maximum                  |
| Isolation                      | Measurement system to PC                                           | 500 VDC minimum                |

Table 31. AC power requirements

| Parameter                  | Conditions | Specification   |
|----------------------------|------------|-----------------|
| Output voltage             |            | +5 V, $\pm 5\%$ |
| Output wattage             |            | 10 watts        |
| Power jack configuration   |            | Two conductor   |
| Power jack barrel diameter |            | 6.3 mm          |
| Power jack pin diameter    |            | 2.0 mm          |
| Power jack polarity        |            | Center positive |

**Note 8:** This is the total quiescent current requirement for the USB-2416-4AO which includes up to 10 mA for the status LED. This does not include any potential loading of the digital I/O bits, +5V user terminal or the VDAX outputs

**Note 9:** This specification applies to the actual voltage level at the input to the external power connector of the USB-2416-4AO.

## USB specifications

Table 32. USB specifications

|                      |                                                                                            |
|----------------------|--------------------------------------------------------------------------------------------|
| USB device type      | USB 2.0 (full-speed)                                                                       |
| Device compatibility | USB 1.1, USB 2.0                                                                           |
| USB cable type       | A-B cable, UL type AWM 2527 or equivalent. (minimum 24 AWG VBUS/GND, minimum 28 AWG D+/D-) |
| USB cable length     | 5 meters maximum                                                                           |

## Environmental

The environmental specifications listed in Table 33 apply only to the USB-2416-4AO and not to the AC power adapter.

Table 33. Environmental specifications

|                             |                                 |
|-----------------------------|---------------------------------|
| Operating temperature range | 0 to 50° C maximum              |
| Storage temperature range   | -40 to 85 ° C maximum           |
| Humidity                    | 0 to 90% non-condensing maximum |

## Mechanical

Table 34. Mechanical specifications

|                        |                                     |
|------------------------|-------------------------------------|
| Dimensions             | 245 mm (L) x 146 mm (W) x 50 mm (H) |
| User connection length | 5 meters maximum                    |

## Screw terminal connector type and pin-out

Table 35. Screw terminal connector specifications

|                  |                           |
|------------------|---------------------------|
| Connector type   | Detachable screw terminal |
| Wire gauge range | 16 AWG to 30 AWG          |

## Screw terminal pin out

For additional channel configurations when using the optional AI-EXP expansion device, refer to the "Optional AI-EXP32 expansion module" section on page 44.

Table 36. 16-channel differential mode pin out

Do not connect to terminal block pins labeled "NC."

| Pin | Signal name | Pin description   | Pin | Signal name | Pin description      |
|-----|-------------|-------------------|-----|-------------|----------------------|
| 1   | NC          | No connect        | 49  | NC          | No connect           |
| 2   | CH0H        | Channel 0 HI      | 50  | CH15L       | Channel 15 LO        |
| 3   | CH0L        | Channel 0 LO      | 51  | CH15H       | Channel 15 HI        |
| 4   | NC          | No connect        | 52  | IC14        | No connect           |
| 5   | IC0         | No connect        | 53  | 4WC14       | No connect           |
| 6   | CH1H        | Channel 1 HI      | 54  | CH14L       | Channel 14 LO        |
| 7   | CH1L        | Channel 1 LO      | 55  | CH14H       | Channel 14 HI        |
| 8   | 4WC1        | No connect        | 56  | IC13        | No connect           |
| 9   | IC1         | No connect        | 57  | 4WC13       | No connect           |
| 10  | CH2H        | Channel 2 HI      | 58  | CH13L       | Channel 13 LO        |
| 11  | CH2L        | Channel 2 LO      | 59  | CH13H       | Channel 13 HI        |
| 12  | 4WC2        | No connect        | 60  | IC12        | No connect           |
| 13  | IC2         | No connect        | 61  | 4WC12       | No connect           |
| 14  | CH3H        | Channel 3 HI      | 62  | CH12L       | Channel 12 LO        |
| 15  | CH3L        | Channel 3 LO      | 63  | CH12H       | Channel 12 HI        |
| 16  | 4WC3        | No connect        | 64  | IC11        | No connect           |
| 17  | IC3         | No connect        | 65  | 4WC11       | No connect           |
| 18  | GND         | Analog ground     | 66  | GND         | Analog ground        |
| 19  | CH4H        | Channel 4 HI      | 67  | CH11L       | Channel 11 LO        |
| 20  | CH4L        | Channel 4 LO      | 68  | CH11H       | Channel 11 HI        |
| 21  | 4WC4        | No connect        | 69  | IC10        | No connect           |
| 22  | IC4         | No connect        | 70  | 4WC10       | No connect           |
| 23  | CH5H        | Channel 5 HI      | 71  | CH10L       | Channel 10 LO        |
| 24  | CH5L        | Channel 5 LO      | 72  | CH10H       | Channel 10 HI        |
| 25  | 4WC5        | No connect        | 73  | IC9         | No connect           |
| 26  | IC5         | No connect        | 74  | 4WC9        | No connect           |
| 27  | CH6H        | Channel 6 HI      | 75  | CH9L        | Channel 9 LO         |
| 28  | CH6L        | Channel 6 LO      | 76  | CH9H        | Channel 9 HI         |
| 29  | 4WC6        | No connect        | 77  | IC8         | No connect           |
| 30  | IC6         | No connect        | 78  | 4WC8        | No connect           |
| 31  | CH7H        | Channel 7 HI      | 79  | CH8L        | Channel 8 LO         |
| 32  | CH7L        | Channel 7 LO      | 80  | CH8H        | Channel 8 HI         |
| 33  | 4WC7        | No connect        | 81  | GND         | Analog ground        |
| 34  | IC7         | No connect        | 82  | NC          | No connect           |
| 35  | +5V         | +5V output        | 83  | NC          | No connect           |
| 36  | GND         | Analog ground     | 84  | GND         | Analog ground        |
| 37  | VDAC0       | Analog output Ch0 | 85  | DIO7        | Digital input/output |
| 38  | VDAC1       | Analog output Ch1 | 86  | DIO6        | Digital input/output |
| 39  | GND         | Analog ground     | 87  | DIO5        | Digital input/output |
| 40  | VDAC2       | Analog output Ch2 | 88  | DIO4        | Digital input/output |
| 41  | VDAC3       | Analog output Ch3 | 89  | DIO3        | Digital input/output |
| 42  | GND         | Analog ground     | 90  | DIO2        | Digital input/output |
| 43  | CTR0        | Counter input Ch0 | 91  | DIO1        | Digital input/output |
| 44  | GND         | Analog ground     | 92  | DIO0        | Digital input/output |
| 45  | CTR1        | Counter input Ch1 | 93  | DGND        | Digital I/O ground   |
| 46  | GND         | Analog ground     | 94  | DGND        | Digital I/O ground   |
| 47  | NC          | No connect        | 95  | NC          | No connect           |
| 48  | NC          | No connect        | 96  | NC          | No connect           |

Table 37. 32-channel single-ended mode pin out

Do not connect to terminal block pins labeled "NC."

| Pin | Signal name | Pin description   | Pin | Signal name | Pin description      |
|-----|-------------|-------------------|-----|-------------|----------------------|
| 1   | NC          | No connect        | 49  | NC          | No connect           |
| 2   | CH0H        | Channel 0         | 50  | CH15L       | Channel 31           |
| 3   | CH0L        | Channel 16        | 51  | CH15H       | Channel 15           |
| 4   | NC          | No connect        | 52  | IC14        | No connect           |
| 5   | IC0         | No connect        | 53  | 4WC14       | No connect           |
| 6   | CH1H        | Channel 1         | 54  | CH14L       | Channel 30           |
| 7   | CH1L        | Channel 17        | 55  | CH14H       | Channel 14           |
| 8   | 4WC1        | No connect        | 56  | IC13        | No connect           |
| 9   | IC1         | No connect        | 57  | 4WC13       | No connect           |
| 10  | CH2H        | Channel 2         | 58  | CH13L       | Channel 29           |
| 11  | CH2L        | Channel 18        | 59  | CH13H       | Channel 13           |
| 12  | 4WC2        | No connect        | 60  | IC12        | No connect           |
| 13  | IC2         | No connect        | 61  | 4WC12       | No connect           |
| 14  | CH3H        | Channel 3         | 62  | CH12L       | Channel 28           |
| 15  | CH3L        | Channel 19        | 63  | CH12H       | Channel 12           |
| 16  | 4WC3        | No connect        | 64  | IC11        | No connect           |
| 17  | IC3         | No connect        | 65  | 4WC11       | No connect           |
| 18  | GND         | Analog ground     | 66  | GND         | Analog ground        |
| 19  | CH4H        | Channel 4         | 67  | CH11L       | Channel 27           |
| 20  | CH4L        | Channel 20        | 68  | CH11H       | Channel 11           |
| 21  | 4WC4        | No connect        | 69  | IC10        | No connect           |
| 22  | IC4         | No connect        | 70  | 4WC10       | No connect           |
| 23  | CH5H        | Channel 5         | 71  | CH10L       | Channel 26           |
| 24  | CH5L        | Channel 21        | 72  | CH10H       | Channel 10           |
| 25  | 4WC5        | No connect        | 73  | IC9         | No connect           |
| 26  | IC5         | No connect        | 74  | 4WC9        | No connect           |
| 27  | CH6H        | Channel 6         | 75  | CH9L        | Channel 25           |
| 28  | CH6L        | Channel 22        | 76  | CH9H        | Channel 9            |
| 29  | 4WC6        | No connect        | 77  | IC8         | No connect           |
| 30  | IC6         | No connect        | 78  | 4WC8        | No connect           |
| 31  | CH7H        | Channel 7         | 79  | CH8L        | Channel 24           |
| 32  | CH7L        | Channel 23        | 80  | CH8H        | Channel 8            |
| 33  | 4WC7        | No connect        | 81  | GND         | Analog ground        |
| 34  | IC7         | No connect        | 82  | NC          | No connect           |
| 35  | +5V         | +5V output        | 83  | NC          | No connect           |
| 36  | GND         | Analog ground     | 84  | GND         | Analog ground        |
| 37  | VDAC0       | Analog output Ch0 | 85  | DIO7        | Digital input/output |
| 38  | VDAC1       | Analog output Ch1 | 86  | DIO6        | Digital input/output |
| 39  | GND         | Analog ground     | 87  | DIO5        | Digital input/output |
| 40  | VDAC2       | Analog output Ch2 | 88  | DIO4        | Digital input/output |
| 41  | VDAC3       | Analog output Ch3 | 89  | DIO3        | Digital input/output |
| 42  | GND         | Analog ground     | 90  | DIO2        | Digital input/output |
| 43  | CTR0        | Counter input Ch0 | 91  | DIO1        | Digital input/output |
| 44  | GND         | Analog ground     | 92  | DIO0        | Digital input/output |
| 45  | CTR1        | Counter input Ch1 | 93  | DGND        | Digital I/O ground   |
| 46  | GND         | Analog ground     | 94  | DGND        | Digital I/O ground   |
| 47  | NC          | No connect        | 95  | NC          | No connect           |
| 48  | NC          | No connect        | 96  | NC          | No connect           |

## Optional AI-EXP32 expansion module

Use the AI-EXP32 (sold separately) for applications that need additional analog/thermocouple input and digital I/O channels. See Measurement Computing web site for product details.

The AI-EXP32 expansion port is intended to interface with a USB-2416 series product. Do not try to use any of the expansion port pins for any other purpose.

Table 38. AI-EXP32 37-pin connector pin out

Do not connect to terminal block pins labeled "NC."

| Pin | Signal name | Pin description           |
|-----|-------------|---------------------------|
| 1   | GND         | Analog ground             |
| 2   | NC          | No connect                |
| 3   | GND         | Analog ground             |
| 4   | NC          | No connect                |
| 5   | GND         | Analog ground             |
| 6   | VCC         | +12 V power               |
| 7   | NC          | No connect                |
| 8   | NC          | No connect                |
| 9   | IM_A2       | I/O control signal        |
| 10  | IM_A1       | I/O control signal        |
| 11  | IM_A0       | I/O control signal        |
| 12  | IMEN10      | I/O control signal        |
| 13  | IMEN9       | I/O control signal        |
| 14  | IMEN8       | I/O control signal        |
| 15  | IMEN7       | I/O control signal        |
| 16  | DIO_LOAD2   | I/O control signal        |
| 17  | DIO_LOAD1   | I/O control signal        |
| 18  | NC          | No connect                |
| 19  | NC          | No connect                |
| 20  | +3.3V_ISO   | +3.3 V power              |
| 21  | GND         | Analog ground             |
| 22  | +5 VA       | +5 V analog power         |
| 23  | +20.5V      | +20.5 V power             |
| 24  | GND         | Analog ground             |
| 25  | -20.5V      | -20.5 V power             |
| 26  | VDD_ISO     | +5 V digital power        |
| 27  | EXTDIO_INT  | I/O control signal        |
| 28  | CM_A3       | I/O control signal        |
| 29  | SM_A1       | I/O control signal        |
| 30  | SM_AO       | I/O control signal        |
| 31  | CM_A2       | I/O control signal        |
| 32  | SCL         | Serial I/O control signal |
| 33  | SDA         | Serial I/O control signal |
| 34  | MOSI        | Serial I/O control signal |
| 35  | SCK         | Serial I/O control signal |
| 36  | NC          | No connect                |
| 37  | NC          | No connect                |

The multiple-channel throughput rate calculation is based on the following formula:

$$\text{Maximum throughput} = \frac{1}{\sum_n \left( \frac{1}{\text{data rate}} + 640 \mu\text{s} \right)}, \text{ where } n \text{ is the number of channels}$$

Table 39. Multiple-channel throughput rate specifications (Hz),  
USB-2416-4AO and optional AI-EXP32 expansion module

|                          | 3750 S/s | 2000 S/s | 1000 S/s | 500 S/s | 100 S/s | 60 S/s | 50 S/s | 25 S/s | 10 S/s | 5 S/s | 2.5 S/s |
|--------------------------|----------|----------|----------|---------|---------|--------|--------|--------|--------|-------|---------|
| Number of input channels |          |          |          |         |         |        |        |        |        |       |         |
| 1                        | 1102.94  | 877.19   | 609.76   | 378.79  | 93.98   | 57.78  | 48.45  | 24.61  | 9.94   | 4.98  | 2.50    |
| 2                        | 551.47   | 438.60   | 304.88   | 189.39  | 46.99   | 28.89  | 24.22  | 12.30  | 4.97   | 2.49  | 1.25    |
| 3                        | 367.65   | 292.40   | 203.25   | 126.26  | 31.33   | 19.26  | 16.15  | 8.20   | 3.31   | 1.66  | 0.83    |
| 4                        | 275.74   | 219.30   | 152.44   | 94.70   | 23.50   | 14.45  | 12.11  | 6.15   | 2.48   | 1.25  | 0.62    |
| 5                        | 220.59   | 175.44   | 121.95   | 75.76   | 18.80   | 11.56  | 9.69   | 4.92   | 1.99   | 1.00  | 0.50    |
| 6                        | 183.82   | 146.20   | 101.63   | 63.13   | 15.66   | 9.63   | 8.07   | 4.10   | 1.66   | 0.83  | 0.42    |
| 7                        | 157.56   | 125.31   | 87.11    | 54.11   | 13.43   | 8.25   | 6.92   | 3.52   | 1.42   | 0.71  | 0.36    |
| 8                        | 137.87   | 109.65   | 76.22    | 47.35   | 11.75   | 7.22   | 6.06   | 3.08   | 1.24   | 0.62  | 0.31    |
| 9                        | 122.55   | 97.47    | 67.75    | 42.09   | 10.44   | 6.42   | 5.38   | 2.73   | 1.10   | 0.55  | 0.28    |
| 10                       | 110.29   | 87.72    | 60.98    | 37.88   | 9.40    | 5.78   | 4.84   | 2.46   | 0.99   | 0.50  | 0.25    |
| 11                       | 100.27   | 79.74    | 55.43    | 34.44   | 8.54    | 5.25   | 4.40   | 2.24   | 0.90   | 0.45  | 0.23    |
| 12                       | 91.91    | 73.10    | 50.81    | 31.57   | 7.83    | 4.82   | 4.04   | 2.05   | 0.83   | 0.42  | 0.21    |
| 13                       | 84.84    | 67.48    | 46.90    | 29.14   | 7.23    | 4.44   | 3.73   | 1.89   | 0.76   | 0.38  | 0.19    |
| 14                       | 78.78    | 62.66    | 43.55    | 27.06   | 6.71    | 4.13   | 3.46   | 1.76   | 0.71   | 0.36  | 0.18    |
| 15                       | 73.53    | 58.48    | 40.65    | 25.25   | 6.27    | 3.85   | 3.23   | 1.64   | 0.66   | 0.33  | 0.17    |
| 16                       | 68.93    | 54.82    | 38.11    | 23.67   | 5.87    | 3.61   | 3.03   | 1.54   | 0.62   | 0.31  | 0.16    |
|                          |          |          |          |         |         |        |        |        |        |       |         |
| 17                       | 64.88    | 51.60    | 35.87    | 22.28   | 5.53    | 3.40   | 2.85   | 1.45   | 0.58   | 0.29  | 0.15    |
| 18                       | 61.27    | 48.73    | 33.88    | 21.04   | 5.22    | 3.21   | 2.69   | 1.37   | 0.55   | 0.28  | 0.14    |
| 19                       | 58.05    | 46.17    | 32.09    | 19.94   | 4.95    | 3.04   | 2.55   | 1.30   | 0.52   | 0.26  | 0.13    |
| 20                       | 55.15    | 43.86    | 30.49    | 18.94   | 4.70    | 2.89   | 2.42   | 1.23   | 0.50   | 0.25  | 0.12    |
| 21                       | 52.52    | 41.77    | 29.04    | 18.04   | 4.48    | 2.75   | 2.31   | 1.17   | 0.47   | 0.24  | 0.12    |
| 22                       | 50.13    | 39.87    | 27.72    | 17.22   | 4.27    | 2.63   | 2.20   | 1.12   | 0.45   | 0.23  | 0.11    |
| 23                       | 47.95    | 38.14    | 26.51    | 16.47   | 4.09    | 2.51   | 2.11   | 1.07   | 0.43   | 0.22  | 0.11    |
| 24                       | 45.96    | 36.55    | 25.41    | 15.78   | 3.92    | 2.41   | 2.02   | 1.03   | 0.41   | 0.21  | 0.10    |
| 25                       | 44.12    | 35.09    | 24.39    | 15.15   | 3.76    | 2.31   | 1.94   | 0.98   | 0.40   | 0.20  | 0.10    |
| 26                       | 42.42    | 33.74    | 23.45    | 14.57   | 3.61    | 2.22   | 1.86   | 0.95   | 0.38   | 0.19  | 0.10    |
| 27                       | 40.85    | 32.49    | 22.58    | 14.03   | 3.48    | 2.14   | 1.79   | 0.91   | 0.37   | 0.18  | 0.09    |
| 28                       | 39.39    | 31.33    | 21.78    | 13.53   | 3.36    | 2.06   | 1.73   | 0.88   | 0.35   | 0.18  | 0.09    |
| 29                       | 38.03    | 30.25    | 21.03    | 13.06   | 3.24    | 1.99   | 1.67   | 0.85   | 0.34   | 0.17  | 0.09    |
| 30                       | 36.76    | 29.24    | 20.33    | 12.63   | 3.13    | 1.93   | 1.61   | 0.82   | 0.33   | 0.17  | 0.08    |
| 31                       | 35.58    | 28.30    | 19.67    | 12.22   | 3.03    | 1.86   | 1.56   | 0.79   | 0.32   | 0.16  | 0.08    |
| 32                       | 34.47    | 27.41    | 19.05    | 11.84   | 2.94    | 1.81   | 1.51   | 0.77   | 0.31   | 0.16  | 0.08    |

## AI-EXP32 screw terminal pin out

Table 40. 32-channel differential mode pin out

Do not connect to terminal block pins labeled "NC."

| Pin | Signal name | Pin description      | Pin | Signal name | Pin description      |
|-----|-------------|----------------------|-----|-------------|----------------------|
| 1   | CH16H       | Channel 16 HI        | 49  | CH31L       | Channel 31 LO        |
| 2   | CH16L       | Channel 16 LO        | 50  | CH31H       | Channel 31 HI        |
| 3   | CH17H       | Channel 17 HI        | 51  | CH30L       | Channel 30 LO        |
| 4   | CH17L       | Channel 17 LO        | 52  | CH30H       | Channel 30 HI        |
| 5   | CH18H       | Channel 18 HI        | 53  | CH29L       | Channel 29 LO        |
| 6   | CH18L       | Channel 18 LO        | 54  | CH29H       | Channel 29 HI        |
| 7   | CH19H       | Channel 19 HI        | 55  | CH28L       | Channel 28 LO        |
| 8   | CH19L       | Channel 19 LO        | 56  | CH28H       | Channel 28 HI        |
| 9   | CH20H       | Channel 20 HI        | 57  | CH27L       | Channel 27 LO        |
| 10  | CH20L       | Channel 20 LO        | 58  | CH27H       | Channel 27 HI        |
| 11  | CH21H       | Channel 21 HI        | 59  | CH26L       | Channel 26 LO        |
| 12  | CH21L       | Channel 21 LO        | 60  | CH26H       | Channel 26 HI        |
| 13  | CH22H       | Channel 22 HI        | 61  | CH25L       | Channel 25 LO        |
| 14  | CH22L       | Channel 22 LO        | 62  | CH25H       | Channel 25 HI        |
| 15  | CH23H       | Channel 23 HI        | 63  | CH24L       | Channel 24 LO        |
| 16  | CH23L       | Channel 23 LO        | 64  | CH24H       | Channel 24 HI        |
| 17  | GND         | Analog ground        | 65  | GND         | Analog ground        |
| 18  | GND         | Analog ground        | 66  | GND         | Analog ground        |
| 19  | +5VUSER     | +5V output           | 67  | NC          | No connect           |
| 20  | NC          | No connect           | 68  | NC          | No connect           |
| 21  | DIO8        | Digital input/output | 69  | DIO23       | Digital input/output |
| 22  | DIO9        | Digital input/output | 70  | DIO22       | Digital input/output |
| 23  | DIO10       | Digital input/output | 71  | DIO21       | Digital input/output |
| 24  | DIO11       | Digital input/output | 72  | DIO20       | Digital input/output |
| 25  | DIO12       | Digital input/output | 73  | DIO19       | Digital input/output |
| 26  | DIO13       | Digital input/output | 74  | DIO18       | Digital input/output |
| 27  | DIO14       | Digital input/output | 75  | DIO17       | Digital input/output |
| 28  | DIO15       | Digital input/output | 76  | DIO16       | Digital input/output |
| 29  | DGND        | Digital ground       | 77  | DGND        | Digital ground       |
| 30  | DGND        | Digital ground       | 78  | DGND        | Digital ground       |
| 31  | NC          | No connect           | 79  | NC          | No connect           |
| 32  | NC          | No connect           | 80  | NC          | No connect           |

Table 41. 32-channel single-ended mode pin out

Do not connect to terminal block pins labeled "NC."

| Pin | Signal name | Pin description      | Pin | Signal name | Pin description      |
|-----|-------------|----------------------|-----|-------------|----------------------|
| 1   | CH16H       | Channel 16           | 33  | CH31L       | Channel 63           |
| 2   | CH16L       | Channel 48           | 34  | CH31H       | Channel 31           |
| 3   | CH17H       | Channel 17           | 35  | CH30L       | Channel 62           |
| 4   | CH17L       | Channel 49           | 36  | CH30H       | Channel 30           |
| 5   | CH18H       | Channel 18           | 37  | CH29L       | Channel 61           |
| 6   | CH18L       | Channel 50           | 38  | CH29H       | Channel 29           |
| 7   | CH19H       | Channel 19           | 39  | CH28L       | Channel 60           |
| 8   | CH19L       | Channel 51           | 40  | CH28H       | Channel 28           |
| 9   | CH20H       | Channel 20           | 41  | CH27L       | Channel 59           |
| 10  | CH20L       | Channel 52           | 42  | CH27H       | Channel 27           |
| 11  | CH21H       | Channel 21           | 43  | CH26L       | Channel 58           |
| 12  | CH21L       | Channel 53           | 44  | CH26H       | Channel 26           |
| 13  | CH22H       | Channel 22           | 45  | CH25L       | Channel 57           |
| 14  | CH22L       | Channel 54           | 46  | CH25H       | Channel 25           |
| 15  | CH23H       | Channel 23           | 47  | CH24L       | Channel 56           |
| 16  | CH23L       | Channel 55           | 48  | CH24H       | Channel 24           |
| 17  | GND         | Analog ground        | 49  | GND         | Analog ground        |
| 18  | GND         | Analog ground        | 50  | GND         | Analog ground        |
| 19  | +5VUSER     | +5V output           | 51  | NC          | No connect           |
| 20  | NC          | No connect           | 52  | NC          | No connect           |
| 21  | DIO8        | Digital input/output | 69  | DIO23       | Digital input/output |
| 22  | DIO9        | Digital input/output | 70  | DIO22       | Digital input/output |
| 23  | DIO10       | Digital input/output | 71  | DIO21       | Digital input/output |
| 24  | DIO11       | Digital input/output | 72  | DIO20       | Digital input/output |
| 25  | DIO12       | Digital input/output | 73  | DIO19       | Digital input/output |
| 26  | DIO13       | Digital input/output | 74  | DIO18       | Digital input/output |
| 27  | DIO14       | Digital input/output | 75  | DIO17       | Digital input/output |
| 28  | DIO15       | Digital input/output | 76  | DIO16       | Digital input/output |
| 29  | DGND        | Digital ground       | 61  | DGND        | Digital ground       |
| 30  | DGND        | Digital ground       | 62  | DGND        | Digital ground       |
| 31  | NC          | No connect           | 63  | NC          | No connect           |
| 32  | NC          | No connect           | 64  | NC          | No connect           |

## USB-2416-4AO screw terminal pin out (with AI-EXP32 attached)

Table 42. USB-2416-4AO single-ended mode pin out with AI-EXP32 connected

Do not connect to terminal block pins labeled "NC."

| Pin | Signal name | Pin description   | Pin | Signal name | Pin description      |
|-----|-------------|-------------------|-----|-------------|----------------------|
| 1   | NC          | No connect        | 49  | NC          | No connect           |
| 2   | CH0H        | Channel 0         | 50  | CH15L       | Channel 47           |
| 3   | CH0L        | Channel 32        | 51  | CH15H       | Channel 15           |
| 4   | NC          | No connect        | 52  | IC14        | No connect           |
| 5   | IC0         | No connect        | 53  | 4WC14       | No connect           |
| 6   | CH1H        | Channel 1         | 54  | CH14L       | Channel 46           |
| 7   | CH1L        | Channel 33        | 55  | CH14H       | Channel 14           |
| 8   | 4WC1        | No connect        | 56  | IC13        | No connect           |
| 9   | IC1         | No connect        | 57  | 4WC13       | No connect           |
| 10  | CH2H        | Channel 2         | 58  | CH13L       | Channel 45           |
| 11  | CH2L        | Channel 34        | 59  | CH13H       | Channel 13           |
| 12  | 4WC2        | No connect        | 60  | IC12        | No connect           |
| 13  | IC2         | No connect        | 61  | 4WC12       | No connect           |
| 14  | CH3H        | Channel 3         | 62  | CH12L       | Channel 44           |
| 15  | CH3L        | Channel 35        | 63  | CH12H       | Channel 12           |
| 16  | 4WC3        | No connect        | 64  | IC11        | No connect           |
| 17  | IC3         | No connect        | 65  | 4WC11       | No connect           |
| 18  | GND         | Analog ground     | 66  | GND         | Analog ground        |
| 19  | CH4H        | Channel 4         | 67  | CH11L       | Channel 43           |
| 20  | CH4L        | Channel 36        | 68  | CH11H       | Channel 11           |
| 21  | 4WC4        | No connect        | 69  | IC10        | No connect           |
| 22  | IC4         | No connect        | 70  | 4WC10       | No connect           |
| 23  | CH5H        | Channel 5         | 71  | CH10L       | Channel 42           |
| 24  | CH5L        | Channel 37        | 72  | CH10H       | Channel 10           |
| 25  | 4WC5        | No connect        | 73  | IC9         | No connect           |
| 26  | IC5         | No connect        | 74  | 4WC9        | No connect           |
| 27  | CH6H        | Channel 6         | 75  | CH9L        | Channel 41           |
| 28  | CH6L        | Channel 38        | 76  | CH9H        | Channel 9            |
| 29  | 4WC6        | No connect        | 77  | IC8         | No connect           |
| 30  | IC6         | No connect        | 78  | 4WC8        | No connect           |
| 31  | CH7H        | Channel 7         | 79  | CH8L        | Channel 40           |
| 32  | CH7L        | Channel 39        | 80  | CH8H        | Channel 8            |
| 33  | 4WC7        | No connect        | 81  | GND         | Analog ground        |
| 34  | IC7         | No connect        | 82  | NC          | No connect           |
| 35  | +5V         | +5V output        | 83  | NC          | No connect           |
| 36  | GND         | Analog ground     | 84  | GND         | Analog ground        |
| 37  | VDAC0       | Analog output Ch0 | 85  | DIO7        | Digital input/output |
| 38  | VDAC1       | Analog output Ch1 | 86  | DIO6        | Digital input/output |
| 39  | GND         | Analog ground     | 87  | DIO5        | Digital input/output |
| 40  | VDAC2       | Analog output Ch2 | 88  | DIO4        | Digital input/output |
| 41  | VDAC3       | Analog output Ch3 | 89  | DIO3        | Digital input/output |
| 42  | GND         | Analog ground     | 90  | DIO2        | Digital input/output |
| 43  | CTR0        | Counter input Ch0 | 91  | DIO1        | Digital input/output |
| 44  | GND         | Analog ground     | 92  | DIO0        | Digital input/output |
| 45  | CTR1        | Counter input Ch1 | 93  | DGND        | Digital I/O ground   |
| 46  | GND         | Analog ground     | 94  | DGND        | Digital I/O ground   |
| 47  | NC          | No connect        | 95  | NC          | No connect           |
| 48  | NC          | No connect        | 96  | NC          | No connect           |

# CE Declaration of Conformity

Manufacturer: Measurement Computing Corporation  
Address: 10 Commerce Way  
Suite 1008  
Norton, MA 02766  
USA  
Category: Electrical equipment for measurement, control and laboratory use.

Measurement Computing Corporation declares under sole responsibility that the product

## USB-2416-4AO

to which this declaration relates is in conformity with the relevant provisions of the following standards or other documents:

EC EMC Directive 2004/108/EC: General Requirements, EN 61326-1:2006 (IEC 61326-1:2005).

Emissions:

- EN 55011 (2007) / CISPR 11(2003): Radiated emissions: Group 1, Class A
- EN 55011 (2007) / CISPR 11(2003): Conducted emissions: Group 1, Class A

Immunity: EN 61326-1:2006, Table 3.

- IEC 61000-4-2 (2001): Electrostatic Discharge immunity.
- IEC 61000-4-3 (2002): Radiated Electromagnetic Field immunity.
- IEC 61000-4-4 (2004): Electric Fast Transient Burst Immunity.
- IEC 61000-4-5 (2001): Surge Immunity.
- IEC 61000-4-6 (2003): Radio Frequency Common Mode Immunity.
- IEC 61000-4-11 (2004): Voltage Interrupts.

To maintain compliance to the standards of this declaration, the following conditions must be met.

- The host computer, peripheral equipment, power sources, and expansion hardware must be CE compliant.
- All I/O cables must be shielded, with the shields connected to ground.
- I/O cables must be less than 3 meters (9.75 feet) in length.
- The host computer must be properly grounded.
- Equipment must be operated in a controlled electromagnetic environment as defined by Standards EN 61326-1:2006, or IEC 61326-1:2005.

Declaration of Conformity based on tests conducted by Chomerics Test Services, Woburn, MA 01801, USA in July, 2008. Test records are outlined in Chomerics Test Report #EMI5075.08. Further testing was conducted by Chomerics Test Services, Woburn, MA. 01801, USA in February, 2009. Test records are outlined in Chomerics Test report #EMI5271.09.

We hereby declare that the equipment specified conforms to the above Directives and Standards.



Carl Haapaoja, Director of Quality Assurance

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